Cascadia Research Collective

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FINAL REPORT

MARINE MAMMAL EXPOSURE TO PCB AND DDT CONTAMINATION IN THE SOUTHERN CALIFORNIA BIGHT

Prepared by

John Calambokidis
John Francis

Cascadia Research
218½ W Fourth Ave.
Olympia, WA 98501

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Waterstreet Building Suite 201 218 1/2 West Fourth Ave Olympia, Washington 98501 (206) 943-7325

SIGNATURE PAGE

John Calambokidis

John Calambokidis
Research Biologist

John Francis

John Francis, PhD
Research Biologist

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INTRODUCTION

The goal of this report is to summarize biological and contaminant-related information on marine mammals in the Southern California Bight that is relevant to PCB and DDT contamination. Information is available, although not all published, on the distribution, food habits, population size and trends, reproduction, mortality, and contaminant loads of some marine mammal species.

The following sections of this report review:

1) the methods used in this study to gather and summarize information on relevant aspects of the biology of marine mammals in the Southern California Bight (SCB) and the presence of PCBs and DDTs.

2) a review of each species occurring in the SCB including relevant background information, information on their occurrence and biology in the SCB, and contaminant loads. Table 1 lists the common and scientific names of marine mammals occurring in the SCB.

METHODS

We conducted a literature search for relevant published and unpublished sources of information. Researchers active in the study of marine mammals in the SCB were contacted to identify additional sources of data that were relevant. In addition to literature identified above, several databases and reviews were used. These included:

Distribution and occurrence in the SCB: We used a database of more than 10,000 sightings of marine mammals made off California from 1975 to 1985 primarily from aerial and ship surveys sponsored by the Minerals Management Service (Ecological Consulting 1993, Bonnell *et al.* 1980, 1983, Dohl *et al.* 1981). Sightings for the SCB were plotted to allow evaluation of occurrence of marine mammals in the study area and their proximity to areas of highest concentrations of PCBs and DDTs. Appendix Figures show the locations of sightings of each marine mammal species in the SCB with different symbols showing sightings made during systematic effort that covered the entire study area (squares) and those made opportunistically (+). Additionally, reviews of marine mammal occurrence in the SCB (Leatherwood *et al.* 1987) were valuable. Sightings from recent systematic aerial and vessel surveys conducted in 1991 and 1992 by Southwest Fisheries Science Center (SWFC) were used for more recent data on distribution (Barlow 1993, Forney and Barlow, In press, Hill and Barlow 1992).

Population size and trends: Pinniped abundance estimates and trends were evaluated using the counts made on haul-out areas and rookeries (*e.g.* Hanan and Beeson 1994 for harbor seals). Current abundance estimates and trends in the abundance of cetaceans in SCB and California waters were primarily evaluated based on the results of the aerial and vessel surveys conducted by SWFC (Barlow 1993, In press, Forney and Barlow, In press). The 1993 workshop on status of California cetacean stocks held at SWFC (Barlow *et al.* 1993a) provided an important evaluation and critique of the current reports related to the status of cetaceans off California.

Strandings: Strandings were examined to evaluate occurrence of species, incidences of mortality in different coastal regions, and availability of tissues for contaminant analysis. Data from strandings can reflect occurrence and seasonality of marine mammals in an area (Woodhouse 1991). Strandings of marine mammals were primarily evaluated utilizing the database of strandings reported to National Marine Fisheries Service from 1983 to 1991. This consisted of two RBASE databases covering two time periods (in slightly different formats) that were provided to us. These contained 3,924 records of dead marine mammals from the entire California coast. These databases were used to summarize the number of strandings by species, year, and county in the SCB (Tables 2 and 3). Past reviews of stranded animals in California were also used (Seagars *et al.* 1986, Seagars and Jozwiak 1991).

Contaminant concentrations: Data on DDTs and PCBs in marine mammals in the SCB as well as adjacent areas along the west coast of North America were compiled from published and unpublished sources (Tables 4-10, Figures 1-4). Comparisons to PCB and

DDT concentrations outside of SCB were made relying on original sources and selected contaminant reviews (Wagemann and Muir 1984, Risebrough 1978).

Prey and feeding: The type of prey and evidence for locations of feeding in the SCB were examined for evaluation of likely exposure to PCBs and DDTs from the Damage Assessment area.

SPECIES ACCOUNTS

The accounts for different species are provided below organized by major taxonomic group. See Table 1 for a complete listing of species and scientific names.

ODONTOCETES

A number of odontocetes occur in the SCB but are not considered in detail below because of their infrequent occurrence and the lack of information on contaminant concentrations or potential impacts. These include:

> Beaked whales (family Ziphiidae): Although several members of this family including Baird's and Cuvier's beaked whales are sighted occasionally in the SCB, all of these species are restricted to deeper offshore waters and there is limited information on either contaminant levels or basic biological parameters needed to evaluate impact.
>
> Pygmy and dwarf sperm whales (genus *Kogia*): Similar to the beaked whales, these species occur in offshore waters, are rarely seen, and there are little data available to assess contaminant impacts.
>
> Several of the more tropical delphinids: These include rough-toothed and striped dolphins which are distributed primarily in more southern waters and are not common to the inshore waters of the SCB.
>
> False killer whales: This species, which occasionally occurs in the SCB, has a more tropical or subtropical distribution (Leatherwood *et al.* 1987) and was not included because of the low number of sightings and strandings in the SCB. False killer whales were not seen during SWFC aerial or ship surveys conducted along the entire California coast in 1991 and 1992 (Barlow 1993, Forney and Barlow, In press).

Bottlenose dolphin

Background

Three different forms of the bottlenose dolphin in the North Pacific have been described (Walker 1981). These are: 1) a southern California and Mexico coastal form, 2) a northern temperate offshore form, and 3) an eastern tropical Pacific offshore form. These forms are primarily distinguishable by comparative tooth size but also show differences in skull measurements, food habits, and parasite loads (Walker 1981). There is also some evidence for differences in hematology (Duffield *et al.* 1983).

Although bottlenose dolphins in the eastern North Pacific were seen north through central California from the 1950s through 70s, the SCB was the northern extent of their range (Norris and Prescott 1961, Dohl *et al.* 1981, Wells *et al.* 1990). After 1983, however, there was a expansion of their range and sightings to Monterey Bay became common (Wells *et al.* 1990).

The best estimates of the abundance of bottlenose dolphins are from ship and aerial surveys in 1991 and 1992 for the offshore form and from photographic identification of individual animals for the coastal form (Barlow *et al.* 1993a). Abundance of the offshore form in California waters was 2,098 (CV 0.36) based on averaging the aerial and vessel survey results (Barlow *et al.* 1993a, Barlow 1993, Forney and Barlow, In press). The estimated abundance for the coastal form was 240 based on the number of individuals photographically identified (Hansen 1990).

Observations in SCB

Sightings of bottlenose dolphins indicate a distribution that would expose them to some of the more contaminated areas of the SCB (Appendix Figures). Plotted sightings of bottlenose dolphins in the SCB were distributed both inshore and offshore. Sightings of inshore animals included a cluster of sightings directly off Palos Verdes and scattered sightings north of San Diego. Despite the proximity to shore, these sightings close to Palos Verdes could be animals of the temperate offshore form. Offshore sightings included a large number around Santa Catalina Island. Both the inshore and offshore forms would presumably be in relatively close proximity to areas of high contamination of PCBs and DDTs. Forty-six strandings of bottlenose dolphins were reported to NMFS for 1983-91 with most of these occurring in San Diego and Orange Counties (Table 2). The strandings were evenly distributed across years during this time period (Table 3).

Bottlenose dolphins in different areas exhibit both a high degree of seasonal movements or a high degree of site fidelity (Wells *et al.* 1990). In southern California, bottlenose dolphins observed through the early 1980s were considered resident to the SCB (Dohl *et al.* 1981) and individual identification showed some fidelity to the area (Hansen 1990). The long range movements described above in 1983 (Wells *et al.* 1990) as well as subsequent studies of identified individuals have shown a higher degree of movement and interchange (Hansen and Defran 1990). The range for these movements appears to be between San Quintin and Ensenada, Baja California to the south (Caldwell *et al.* 1993) and Monterey Bay to the north (Wells *et al.* 1990). Coastal bottlenose dolphins are typically seen within 1 km of shore and are seen year-round (Hansen 1990, Hansen and Defran 1993).

There appears to be site fidelity in some of offshore animals seen around Santa Catalina and Santa Barbara Islands. Eric Martin (pers. comm.) has seen one group of animals consistently in this area from 1988 through early 1994. His sightings were made year-round and the group was encountered during about three quarters of the regular trips to the area.

The prey of coastal bottlenose dolphins in southern California consists of a number of fish and invertebrates (Walker 1981). Primary fish prey were croakers (Family Sciaenidae) including queenfish and white croaker and surfperches (Family Embiotocidae) including walleye and white surfperch (Walker 1981). Norris and Prescott (1961) reported similar findings of a variety of prey including white croaker, queenfish, corbina, and barred surfperch, as well as other fish and a variety of invertebrates in the stomach of an adult female coastal bottlenose dolphin. Both the croakers and surfperches as well as other prey are primarily species that inhabit coastal inshore marine and estuarine waters (Eschmeyer *et al.* 1983).

Contaminant concentrations

High concentrations of PCBs and DDTs have been found in the tissues of coastal bottlenose dolphins from the SCB based on four data sources (Table 5, Figures 1-4). Concentrations in the blubber of 12 bottlenose dolphins recovered between 1971 and 1986 ranged from 126 to 2,700 ppm wet weight (GM = 688) for total DDTs and from 3.1 to 450 ppm wet weight (GM = 70) for PCBs.

Most of the stranded animals used in these analyses were from the coastal form (W. Walker, pers. comm.). The only known exception was an animal collected off Catalina Island in 1971 that died in captivity shortly after capture (Gerlinger 1971). This animal had concentrations of total DDTs and PCBs in blubber of 195 and 115 ppm, wet weight, in the low range of the results for coastal animals but higher than most other marine mammals.

We examined for significant statistical associations within this dataset. Concentrations of total DDTs or PCBs in blubber did not vary significantly among the three studies that had multiple samples or by gender (ANOVA, $p>0.05$ for all cases). A step-wise linear regression was used to identify significant variables affecting concentrations. For total DDT in blubber, concentrations were directly correlated with length of the animal (regression, $p=0.01$). PCB concentrations were directly correlated with length and inversely correlated with collection year (multiple regression, $p<0.001$). The finding of increasing concentrations with length is consistent with the accumulation of these contaminants with age. The decreasing concentration of PCBs with year is also consistent with trends in other organisms from the SCB (Mearns *et al.* 1991). The lack of such an association for DDTs may be the result of the small sample size or the presence of other confounding variables.

The concentrations of DDTs found in bottlenose dolphins from the SCB are among the highest reported for any marine mammal (O'Shea *et al.* 1980, Wagemann and Muir 1984). The concentrations were similar to those found in the adult female California sea lions giving birth to premature pups on San Miguel Island (DeLong *et al.* 1973, Gilmartin *et al.* 1976). Concentrations also were higher than found in bottlenose dolphins that died in the 1987-88 mass mortality on the east coast of the U.S., although this comparison is complicated by differences in methods and reporting of values (Geraci 1989). That mass-mortality was primarily attributed to a natural toxin with contaminants potentially playing a contributing role (Geraci 1989).

The principal prey of coastal bottlenose dolphins are some of the most contaminated marine organisms in the SCB. White croaker had the highest concentrations of PCBs and DDTs in muscle tissue among 16 species of fish tested in the SCB in 1987 and was the single species in their most contaminated category (Pollock *et al.* 1991). Geometric mean concentrations (n=5) of PCBs and total DDTs in edible tissues of white croaker were 0.25 and 2.1 ppm wet weight at White's Point and 0.5 and 2.6 ppm wet weight at Point Vicente, the two most contaminated sites sampled. Other primary prey of bottlenose dolphins, including queenfish, corbina, and surfperches were in the second most contaminated group (of four categories) of fish species (Pollock *et al.* 1991).

Conclusions

The distribution and food habits of bottlenose dolphins expose them to high contaminant PCBs and DDTs in the SCB. This is consistent with the high concentrations of these compounds found in bottlenose dolphins.

Common dolphins

Background

Two forms of common dolphins have recently become recognized for the eastern North Pacific (Heyning and Perrin 1994). The two forms, proposed as the short-beaked (*Delphinus delphis*) and long-beaked (*Delphinus capensis*), can be distinguished by total length, beak length, and color pattern (Heyning and Perrin 1994). Although these two forms are likely to be widely recognized as distinct species, most of the past data do not distinguish between these forms and so this section will deal with both together.

The abundance of common dolphins off California was estimated at just under 250,000 from vessel surveys in summer/fall 1991 (Barlow 1993, Barlow *et al.* 1993a). Most of these were the short-beaked form seen in offshore waters with only about 10,000 of the long-beaked coastal form.

There has been a substantial increase in abundance of common dolphins off California in the late 1970s and early 1980s to the 1990s. In the late 1970s and early 1980s, an estimated 57,000 common dolphins occurred off southern California (Dohl *et al.* 1981, 1986) and none were seen off central and northern California (Dohl *et al.* 1983). Barlow (1993) suggested the increase to 250,000 by 1991 was the result of a northward shift in distribution. This was apparent from the frequent sightings off central and northern California in 1991, where they had been absent from before.

Observations in SCB

Common dolphins are the most abundant cetacean in the SCB (Dohl *et al.* 1981, 1986) and were sighted throughout the SCB including coastal and offshore waters (Appendix Figures). Common dolphins are the most frequent cetacean stranding in the SCB (Tables 2 and 3). Strandings have been frequent in all counties including 27 in Los Angeles County and 110 in the entire SCB from 1983-91. Heyning and Perrin (1994) report large changes in the proportion of short-beaked and long-beaked form common dolphins stranding in southern California by year. Some years, like 1975-77, all strandings were of short-beaked, while other times, such as the mid-1980s, most or all strandings were of long-beaked.

The diet of common dolphins off southern California varies by season. Evans (1975) reported common dolphins fed primarily on anchovies and squid in the fall and winter and deep-sea smelt and various lantern fishes in the spring and summer. A total 19 species of fish were found in the stomachs of the 36 common dolphins collected (Evans 1975). Fiscus and Niggol (1965) found lanternfish, squid, saury, and anchovy in the stomachs of four common dolphins collected off southern California (35°-36° N) in February and March 1959. Fitch and Brownell (1968) found primarily whiting (hake) and anchovy in the stomachs of two animals from the SCB. Heyning and Perrin (1994) suggested that short-beaked common dolphins may feed more extensively on squid than the long-beaked form, though this was based on a very small sample.

Contaminant concentrations

Levels of PCBs and DDTs in common dolphins, as measured by three primary studies were higher than most other species (Table 4, Figures 1-4). Concentrations in the blubber of 26 common dolphins recovered between 1971 and 1984 ranged from 1.2 to 1,800 ppm wet weight (GM = 318) for total DDTs and from 0.08 to 300 ppm wet weight (GM = 34) for PCBs. Concentrations in the liver of 19 animals ranged from 0.76 to 107 ppm wet weight (GM = 12.6) for total DDTs and from 0.0 to 19 ppm wet weight (GM = 3.4) for PCBs. The mean concentrations in blubber were about half those in bottlenose dolphins, but the difference was not statistically significant ($p>0.05$). There were no significant statistical associations in blubber concentrations of PCBs or DDTs by length or sex in the pooled sampled ($P>0.05$ for all cases).

Northern anchovies, one of the principle prey of common dolphins, have varied contaminant loads. Edible tissues of Northern anchovies had mean concentrations of total DDTs of 0.047 ppm, wet weight in "coastal waters" and 0.121 ppm in Los Angeles Harbor and PCBs of 0.008 and 0.065 ppm at the two sites, respectively (data summarized in Mearns *et al.* 1991). These concentrations appeared generally intermediate compared to other fish species summarized in Mearns *et al.* (1991).

There were significant differences in concentrations of both PCBs and total DDTs in blubber, brain, and muscle by study ($p<0.005$ in all cases). These differences were primarily between the higher values from 1974-76 reported by O'Shea *et al.* (1980) and the lower values reported for 1978-84 reported by Schafer *et al.* (1984). Additionally, liver concentrations of PCBs but not total DDTs were significantly higher in the 1971-77 samples by Britt and Howard (1983) compared to the lower values reported for 1978-84 reported by Schafer *et al.* (1984); O'Shea *et al.* (1980) did not report liver values. Three possible explanations for these differences are:

1) **Methodological differences in the analysis and quantification between the studies.** Differences in quantification techniques for PCBs can result in different values. Because the differences were for both PCBs and total DDTs, this explanation appears unlikely.

2) **A decrease in contaminant concentrations over time.** Concentrations of PCBs and DDTs have decreased in the SCB since the 1970s (Mearns *et al.* 1991) and the decrease over time could be real. However, the magnitude of the decrease over such a short period makes it unlikely that this factor could explain the entire difference.

3) **Shifts in the distribution and forms of common dolphins that stranded and were used in the analyses.** There is evidence of dramatic changes in common dolphin distribution and abundance in the SCB that would have altered which animals stranded

and their contaminant loads. There have been changes in the proportion of different forms of common dolphins stranding in southern California, as mentioned above (Heyning and Perrin 1994). During 1974-76 when the samples for O'Shea *et al.* (1980) were collected, most strandings were of the short-beaked form. W. Walker (pers. comm.), who collected these samples provided information that all but one of the samples analyzed was a short-beaked animal. Though we do not know the form of the animals analyzed by Schafer *et al.* (1984), during this period about half the strandings were of the long-beaked form (Heyning and Perrin 1994). As reported in Barlow (1993), there has been a dramatic increase in common dolphin abundance off souther California between the 1970s and 1991, possibly as a result of a northward shift in the distribution of animals.

Concentrations of PCBs and DDTs in common dolphins, like those found in bottlenose dolphins, are high compared to findings in marine mammals from other parts of the world (Wagemann and Muir 1984).

Conclusions

High concentrations of contaminants have been found in the tissues of common dolphins. Abundance of this species in the SCB has increased in recent years and they remain the most abundance cetacean in these waters.

Killer whales

Background

Killer whales occur in all oceans and are top predators in the marine food chain (Heyning and Dahlheim 1988, Bigg *et al.* 1987). Killer whales have been best studied in the waters of British Columbia and Washington State, where two forms have been described (Bigg *et al.* 1987). These two forms, termed "residents" and "transients", differ in vocalizations, food habits, group size, and external morphology (Bigg *et al.* 1987, Baird and Stacey 1988, Baird *et al.* 1992, Ford and Fisher 1982). Differences in mitochondrial DNA indicate they have been reproductively isolated for some time (Hoelzel and Dover 1991, Stevens *et al.* 1989). It has been suspected that some of these same distinctions exist in killer whale populations in other areas.

Although killer whales may be resident to some areas for extended periods or season, they also can range widely. Killer whales individually identified off California have been resighted as far north as British Columbia and Glacier Bay, Alaska, and as far south as San Benitos Islands, Mexico (Black *et al.* 1993).

Prey of killer whales includes a wide variety of fish, cephalopods, pinnipeds, other cetaceans, as well as other prey such as birds, deer, and sea turtles (see reviews by Perrin 1982, Hoyt 1984, Jefferson *et al.* 1991). In some areas, different forms of killer whales show very different prey preferences and feeding behavior (Bigg *et al.* 1987). Fish prey range from small schooling fishes, including herring and sardines, to large fish such as halibut and basking sharks (Hoyt

1984). Documented predation on marine mammals by killer whales has been observed for 20 species of cetaceans, 14 species of pinniped, sea otter, and dugong (Jefferson *et al.* 1991).

Observations in the SCB

There have been relatively few killer whale sightings in the SCB (Appendix Figures). There has been only a single stranding of a killer whale in the SCB (Orange County in 1985) reported to NMFS from 1983-91 (Tables 2 and 3). Dahlheim *et al.* (1982) summarize additional historical sightings and strandings of killer whales in the temperate and tropical eastern Pacific including six strandings or captures and numerous additional historical sightings in the SCB.

Black *et al.* (1993) reported five species of marine mammals as primary prey based on visual observations of killer whales in California waters. Fiscus and Niggol (1965) found remains of four elephant seals, at least one California sea lion, and one cetacean, possibly a Dall's porpoise, in the stomach of one killer whale taken off central California in March 1961. Observations of feeding behavior and stomach contents analysis in the SCB have shown that they feed on gray whales, minke whales, California sea lions, harbor seals, and some fish (Dahlheim *et al.* 1982, Rice 1968, Norris and Prescott 1961, A. Schulman, pers. comm.). Killer whales that feed on California sea lions outside the SCB would be exposed to contaminants from the SCB that the sea lions had accumulated.

Sightings of individually identified killer whales indicate extensive movements by some of the whales that have been seen in the SCB (Schulman and Kelly 1990, Black *et al.* 1993, N. Black, pers. comm.). Killer whales seen in the SCB have been seen in Mexican waters including the Sea of Cortez off La Paz and Bahia de Los Angeles as well as far north as British Columbia. There have been frequent identification matches between the SCB and Monterey Bay.

Repeat sightings of some individuals indicate that the same individuals may repeatedly return to the same areas (Leatherwood *et al.* 1987, Black *et al.* 1993, Schulman and Kelly 1990). One pod of 12-15 whales (A pod) has been seen regularly off Los Angeles (31 sightings) between 5 January 1982 and 24 March 1989 with other sightings in the Sea of Cortez and off Monterey Bay (Schulman and Kelly 1990). The pod consists of 3 adult males and the rest adult females or subadults. Although this pod was seen every year from 1982 to 1991, it has not been seen since Nov. 1991 (A. Schulman, pers. comm. in April 1994). Many of the sightings of A pod are close to shore (within 3 miles of shore) off Palos Verdes Peninsula. Despite the repeated sightings of this group (more than any other killer whale pod off California), there have been no confirmed sightings of calves in this pod. A calf was seen in 1983 with a pod of killer whales near Los Angeles, but no photographs were taken to confirm this was A pod and in 1985 a dead calf (same animal described in Heyning 1988) washed up during the same period A pod was seen in the area (A. Schulman, pers. comm.).

The estimated killer whale population off California is 307 (Barlow 1993). A total of 88 individuals have been photographically identified off California, 40 of these in the SCB (Black *et al.* 1993, N. Black, pers. comm.).

Contaminant concentrations

No contaminant data are available from killer whales in California waters. Contaminant studies in killer whales from Washington, British Columbia, and Alaska demonstrate that they are exposed to high levels of PCBs and DDTs (Calambokidis *et al.* 1984, 1990, Muir *et al.* 1991). Concentrations of PCBs and total DDTs ranged up to 250 and 640 ppm, wet weight, respectively. Transient-type animals that feed on other marine mammals generally had higher concentrations than the fish-eating resident-type animals.

Conclusions

Killer whales are likely exposed to PCBs and DDTs from the SCB either due to feeding in this region or feeding outside this region on California sea lions that carry contaminants from the SCB.

Pacific white-sided dolphin

Background

Pacific white-sided dolphins occur widely through the North Pacific, mostly in more pelagic waters but occasionally close to shore (Leatherwood *et al.* 1982). There appear to be at least two forms in the eastern Pacific, a northern and a southern form, with an overlap zone around 32° - 37° N (Walker *et al.* 1984, 1986). The abundance of Pacific white-sided dolphins in the North Pacific was estimated as 931,000 (Buckland *et al.* 1993b) and 970,000 (Hobbs and Lerczak 1993), though both these estimates were suspected to be biased upward due to attraction to the survey vessel. The abundance of Pacific white-sided dolphins off California was estimated as 103,724 (CV 0.48) based on aerial surveys in winter 1991 and 1992 (Barlow *et al.* 1993a, Forney and Barlow, In press).

Stroud *et al.* (1981) reported a high incidence of numerous types of squid as well as anchovy, whiting, saury, anchovy, and other fish in the stomachs of 36 Pacific white-sided dolphins taken off primarily central California. Fiscus and Niggol (1965) found squid, whiting, and anchovy in the stomachs of five Pacific white-sided dolphins collected off southern and central California (35°-37° N) in February and March 1959. Animals caught in high seas driftnets in the North Pacific had primarily lanternfish (Myctophids), deepsea smelts, argentines, Pacific saury, and squid in their stomachs (Walker and Jones 1993).

Observations in SCB

Pacific white-sided dolphins generally have been sighted in more offshore waters of the SCB, especially around the western side of the northern Channel Islands (Appendix Figures). Strandings of Pacific white-sided dolphins have been fairly common in all the counties of the SCB (Table 2). The number of strandings per year varied from one to six for 1983-91 (Table 3).

Prey of Pacific white-sided dolphins off southern California was summarized by Walker *et al.* (1984). Primary prey based on examination of 23 animals were anchovy, whiting, and squid, in that order. Other prey species included two species of croaker, white croaker and queenfish, some of the more contaminated fish species identified in the SCB (Pollock *et al.* 1991). A few of the animals examined by Fitch and Brownell (1968) and Stroud *et al.* (1981) were from the SCB area and these contained squid, anchovy, whiting, mackerel, and queenfish. An adult male taken off Anacapa Island in the SCB on 27 February 1952 had jellyfish and squid remains in its stomach (Scheffer 1953).

Contaminant concentrations

Concentrations of PCBs and DDTs in two Pacific white-sided dolphins from the SCB were reported by Schafer *et al.* (1984). The concentrations in blubber were different between the two samples with total DDTs of 2.1 and 99 ppm, wet weight and PCBs of 0.23 and 4.9 ppm, wet weight (Table 5). These concentrations are generally lower than found in the other small cetaceans from the SCB. Partial data on contaminant concentrations were also available for eight other Pacific white-sided dolphin that were captured or stranded alive in the SCB in 1970-71 (Gerlinger 1971). Unfortunately the only data we have from these analyses are some unpublished correspondence that only lists total chlorinated hydrocarbons (Gerlinger 1971). These totals, that likely consist mainly of the sum of total DDTs and PCBs, ranged from 279 to 953 ppm, wet weight in blubber and 10.5 to 88.2 ppm, wet weight in liver. These data, although incomplete, indicate higher concentrations than reported in the two samples by Schafer *et al.* (1984).

A Pacific white-sided dolphin captured off California (location or year not given) and held in captivity for 3½ years (fed mackerel and herring from eastern Canada) prior to death had concentrations in blubber of 1023 ppm total DDT and 147 ppm PCBs by wet weight (Taruski *et al.* 1975).

Conclusions

Contaminant concentrations in the small sample appear low to intermediate, although additional partial results were higher.

Northern right-whale dolphin

Background

This unusual-looking dolphin with no dorsal fin is often seen associated with Pacific white-sided dolphins and its distribution in the eastern North Pacific is generally confined to temperate waters between 30° and 50° N (Leatherwood *et al.* 1982). Dohl *et al.* (1983) suggested that there might be separate populations off central and northern California based on a gap in sightings between these two areas of concentration. The abundance of northern right whale dolphins in the entire North Pacific was estimated as 68,000, although this estimate may be biased by vessel avoidance or attraction (Buckland *et al.* 1993b). The abundance of northern right whale dolphins off

California was estimated as 17,118 (CV 0.46) based on aerial surveys in winter 1991 and 1992 (Barlow *et al.* 1993a, Forney and Barlow, In press).

Leatherwood *et al.* (1982) considered squid to be the primary prey of northern right-whale dolphins. Animals caught in high seas driftnets in the North Pacific had prey in their stomachs similar to that found in Pacific white-sided dolphins; primarily lanternfish (Myctophids), deepsea smelts, argentines, Pacific saury, and squid in their stomachs (Walker and Jones 1993). Stomach contents of one animal from the SCB had primarily lanternfish (myctophids) as well as squid and appeared to have been feeding in deeper water (>200 m) (Fitch and Brownell 1968).

Observations in the SCB

Sightings of northern right-whale dolphins were primarily distributed in more offshore waters of the SCB (Appendix Figures). Their occurrence within the SCB is seasonal with no sightings made during systematic surveys from 1975-78 occurring during the warm-water months of July through October (Dohl *et al.* 1981). Immature animals seen during these surveys of the SCB constituted only 0.4% of the total (Dohl *et al.* 1981) compared to 2.2% of the animals seen off central and northern California being newborns or young of the year (Dohl *et al.* 1983). Animals entering the SCB in winter and spring did not likely come from central California but may represent animals that moved from more offshore waters (Dohl *et al.* 1983). There were only three strandings of northern right-whale dolphins reported in the SCB reported to NMFS for 1984-91, with all of these in the Channel Islands (Table 2).

Contaminant concentrations

Contaminant concentrations from only one northern right-whale dolphin from the SCB have been reported (Table 5). Concentrations were 164 ppm total DDTs and 49 ppm, wet weight PCBs in an animal picked up alive near the Santa Monica Pier in 1971 and died a day later (Gerlinger 1971).

Conclusions

This species is generally distributed more offshore than other species and occurs only seasonally in the study area.

Risso's dolphins

Background

Risso's dolphins, also known as grampus, are widely distributed and abundant from tropical waters of the North Pacific north to 50° and generally occur in waters seaward of the 100 fathom line (Leatherwood *et al.* 1982). There are several gaps in the north-south distribution of animals and also evidence of seasonal movements.

This species was the third most abundant cetacean off central and northern California and primarily occupied the outer continental shelf (100 to 1,000 fathoms) waters (Dohl *et al.* 1983). Abundance estimates in early 1980s for central northern California ranged from 13,000 in summer to 30,000 in winter (Dohl *et al.* 1983). The abundance off California in winter 1991 and 1992 was estimated as 27,146 (CV 0.45) based on aerial surveys (Barlow *et al.* 1993a, Forney and Barlow, In press). Abundance estimates for summer and fall 1991 off California were 9,433 (CV 0.40) based on ship surveys (Barlow 1993).

Off central California, the abundance of Risso's dolphin was seasonal and there was a preference for warmer waters along the continental slope and in other areas of steep bottom topography (Kruse 1989). Repeated sightings of the same groups of identified individuals indicate some cohesion in group structure (Kruse 1989). Risso's dolphins feed primarily on cephalopods (Leatherwood *et al.* 1982).

Observations in the SCB

In the SCB, Risso's are seen widely, with most sightings occurring offshore and relatively few sightings near Palos Verdes (Appendix Figures). The distribution of sightings of this species is similar to that of Pacific white-sided and northern right-whale dolphins, with which they are often associated.

Contaminant concentrations

No contaminant concentrations are available for this species in the SCB. Alzieu and Duguy (1979) examined concentrations of PCBs and DDTs in the blubber, liver, kidney, muscle, and stomach of four Risso's dolphin and other delphinids stranded on the French coast in the 1970s. Concentrations of total DDTs in blubber averaged 70 ppm and PCBs 68 ppm, dry weight. These concentrations in blubber were generally lower than in other delphinids they tested, although the concentrations in other tissues of Risso's dolphins were in the middle of the range of values found in other delphinids.

Conclusions

Data on the biology of this species and contaminant concentrations are extremely limited.

Pilot whales

Background

Pilot whales are reported to be abundant in the eastern North Pacific from off Guatemala to Pt. Conception, California, although they occur north to the Gulf of Alaska (Leatherwood *et al.* 1982). There is some confusion and disagreement about the taxonomic status of pilot whales and the existence of separate forms in the North Pacific. With gestation and lactation each longer than a year, their reproductive cycle may take 3 years (Leatherwood *et al.* 1982).

Observations in the SCB

Pilot whales were seen frequently in the 1970s and early 1980s in the SCB with many sightings around Palos Verdes and Santa Catalina Island (Appendix Figures). Eighty-four percent off all sightings of pilot whales during aerial surveys in the 1970s were made around these two areas (Dohl *et al.* 1981).

The number of pilot whales using the near-shore waters off Santa Catalina usually increased in winter apparently to feed on squid (Norris and Prescott 1961, Dohl *et al.* 1981, Shane and McSweeney 1990). Squid remains were recovered from the stomach of a pilot whale found dead off Santa Catalina Island in December 1980 (Seagars and Henderson 1985). The winter population in the SCB in the 1970s was estimated as up to 2,000 (Dohl *et al.* 1981).

Dohl *et al.* (1981) concluded there was a small (<400 animals) resident population in the SCB that primarily frequented Santa Catalina Island and the Palos Verdes Peninsula. Walker (1975) reported there was one specific group of 20-30 pilot whales resident to the Catalina Channel that was identified by distinctive markings and was regularly seen around Catalina, San Clemente, and Santa Barbara Islands as well as off Palos Verdes and Huntington Beach. From 1980 to 1986, photographic identification of animals revealed inter-year resightings of some of the same animals off Santa Catalina Island and interchange with the animals seen off the Palos Verdes Peninsula (Shane and McSweeney 1990). The distribution of pilot whales and their locale was close to areas of high concentrations of PCBs and DDTs.

Pilot whale occurrence in the SCB has decreased sharply since the 1980s. No pilot whales were seen around Santa Catalina Island in 1987 and 1988 despite efforts to locate and identify them (Shane and McSweeney 1990). No sightings of pilot whales were made in the SCB or elsewhere along the California coast during SWFC aerial surveys covering the entire California coast in winters of 1991 and 1992 (Forney and Barlow, In press) or in SWFC ship surveys in summer/fall 1991 (Barlow 1993, Hill and Barlow 1992). The cause for this decline or shift in distribution is not known.

There were six strandings of pilot whales in the SCB reported to NMFS for 1983-91 with three of them on the Channel Islands (Table 2). Three of these occurred in 1983 and the rest scattered across the remaining years (Table 3). Seagars and Henderson (1985) observed six dead pilot whales off Santa Catalina Island in December 1980 and suspected these had died as a result of entanglement in purse seines targeting squid.

Contaminant concentrations

Tissues of seven pilot whales from the SCB have been tested for contaminants (Table 6). Concentrations of total DDTs were 35 and 130 and PCBs were 8.8 and 14, ppm, wet weight in blubber of two animals (O'Shea *et al.* 1980). Hall *et al.* (1971) reported a mean concentration of 1.06 ppm in the liver of five pilot whales that stranded on San Clemente Islands in 1971. These values were intermediate to those found in other species from the SCB (Figures 1-4). A third pilot whale captured off California (location or year not specific) and held in captivity for

6 weeks prior to death had concentrations in blubber of 255 ppm total DDT and 46 ppm PCBs by wet weight (Taruski *et al.* 1975). Long-finned pilot whales from the Faroe Islands had higher concentrations of PCBs and DDTs than other species tested; higher than sperm whales and harbor porpoise and similar to white-sided dolphins (Borrell 1993).

There are some data on contaminants in squid, the primary prey of pilot whales, in the SCB. Edible tissues of three samples of market squid from coastal waters of the SCB taken in 1980-81 had total DDTs of from 0.006 to 0.031 ppm, wet weight, and PCBs of from 0.003 to 0.024 ppm, which are generally lower than found in the edible tissues of most fish from California coastal waters (Mearns *et al.* 1991).

Conclusions

An apparent resident group of pilot whales regularly utilized waters in the 1970s and 1980s in the vicinity of the more contaminated regions of the SCB. This may have exposed these animals to high concentrations of contaminants, although not as high as species such as bottlenose dolphins that feed on more contaminated types of prey. The reason for the disappearance of these animals from these areas in the late 1980s is not known.

Dall's porpoise

Background

Dall's porpoise are widely distributed across the North Pacific (Leatherwood *et al.* 1982). Though they generally prefer colder waters, in the eastern North Pacific their range extends south to Baja California (Jefferson 1988). The abundance of Dall's porpoise in the North Pacific has been estimated as 1,186,000 (Buckland *et al.* 1993b) and 1,590,000 (Hobbs and Lerczak 1993). The abundance of Dall's porpoise off California in 1991 was estimated as 78,422 (CV 0.35) based on vessel surveys (Barlow *et al.* 1993a, Barlow 1993). All these estimates were suspected to be biased high due to attraction to the survey vessel (Buckland *et al.* 1993b, Hobbs and Lerczak 1993). The magnitude of this upward bias could inflate abundance estimates as much as 5-fold (Turnock and Quinn 1991).

Dall's porpoise feed on squid, crustaceans, and many kinds of fish (Leatherwood *et al.* 1982). Squid was the only food remains found in the stomachs of five Dall's porpoise collected off central and northern California in March 1959 (Fiscus and Niggol 1965). Stomach contents of nine Dall's porpoise collected from California to Alaska from 1950 to 1952 consisted of squid, jackmackerel, and capeline (Scheffer 1953).

Observations in the SCB

Sightings of Dall's porpoise are widely distributed throughout the SCB occurring in both inshore and offshore waters (Appendix Figures). A large number of sightings have been made in the Santa Barbara Channel. Stranding of Dall's porpoise in the SCB have been rare; one stranding from Los Angeles County was reported to NMFS from 1983-91 (Table 2).

Dall's porpoise likely feed on a variety of prey in the SCB. Stroud *et al.* (1981) reported several types of squid, as well as whiting, saury, and anchovy in the stomachs of six Dall's porpoise taken off California including one off southern California. A Dall's porpoise collected off Pt. Conception on 26 February 1952 had squid and unidentified fish and in its stomach (Scheffer 1953).

Contaminant concentrations

Tissues of two Dall's porpoise stranded in the SCB in the 1970s have been examined for PCBs and DDTs (Gerlinger 1971, O'Shea *et al.* 1980). Concentrations in blubber were 213 and 246 ppm for total DDT and 108 and 94 ppm for PCBs (Table 5). These concentrations of total DDTs were generally lower than found in the most contaminated marine mammal species in the SCB (Figures 1-4), but were still higher than most cetaceans examined in other parts of the world (Wagemann and Muir 1984). Concentrations of PCBs, however, in these two Dall's porpoise were in the same range as those found in bottlenose and common dolphins from the SCB.

Conclusions

Contaminant concentrations in Dall's porpoise are intermediate compared to other species in the SCB, although their range includes some of the more contaminated waters of the SCB.

Harbor Porpoise

Background

The southern end of the range of harbor porpoise is generally considered Point Conception, so their occurrence in the SCB is uncommon. They are included here primarily because contaminant data on this species provides some insights into the exposure of other marine mammals to contaminants from the SCB.

Harbor porpoise are considered vulnerable to human activities and populations in several other portions of their range have declined or been eliminated (Wolff 1981, Otterlind 1976, Prescott and Fiorelli 1980, Leatherwood and Reeves 1983, Calambokidis *et al.* 1985). Causes for these declines have usually not been identified, although chlorinated hydrocarbon contaminants have been cited as one of the possible reasons (Wolff 1981, Otterlind 1976, Prescott and Fiorelli 1980, Calambokidis *et al.* 1985). Reijnders (1992) concluded that other factors besides pollution were responsible for the decline in harbor porpoise in the North Sea.

Observations in the SCB

Although a few sightings occur in the SCB, most of the sightings are animals close to shore from Point Conception north (Appendix Figures). Only three strandings of harbor porpoise in the SCB were reported to NMFS from 1983-91 and all of these were in Santa Barbara County (Table 2).

Contaminant levels

Concentrations of PCBs and DDTs were examined by 45 harbor porpoise stranded or incidentally caught along the coasts of California, Oregon, and Washington (Calambokidis and Barlow 1991). The concentration of DDE and the ratios of contaminants to each other showed a highly significant geographic pattern that allowed reasonably accurate prediction of where the samples were taken. The highest concentrations of DDE were found at the southern end of the range of harbor porpoise, just north of Point Conception. The one harbor porpoise sampled from just north of the SCB reported by O'Shea *et al.* (1980) is consistent with this pattern and has higher DDE concentrations than any of the samples reported by Calambokidis and Barlow (1991).

Conclusions

Although few harbor porpoise occur in the SCB, the pattern of contaminant concentrations along the west coast indicate increasing concentrations of DDE with closer proximity to the SCB.

Sperm whale

Background

Sperm whales inhabit all oceans of the world and generally occur in offshore waters deeper than 1,000 m (Gosho *et al.* 1984, Leatherwood *et al.* 1982). Deep-water cephalopods are the primary food of sperm whales. Sperm whales generally migrate to higher latitudes during the summer. There is segregation between the sexes with adult males often using higher latitudes.

Sperm whales are listed as endangered due to exploitation during commercial whaling, though their populations remain fairly large. Sperm whale abundance off California (out to 300 nmi) was estimated as 756 (CV 0.49) from vessel surveys in 1991 (Barlow 1993).

Observations in SCB

Sperm whales sightings are relatively rare in the SCB and generally have been made well offshore (Appendix Figures, Leatherwood *et al.* 1987). Only one stranding of a sperm whale in the SCB from 1983-91 has been reported to NMFS (Tables 2 and 3).

Contaminant concentrations

Schafer *et al.* (1984) reported low contaminant concentrations in a male calf sperm whale that stranded in 1983. Concentrations of total DDTs and PCBs were 5.1 and 0.51 ppm, wet weight in blubber (Table 6). These concentrations were lower than the levels found in more coastal or resident cetaceans of the SCB (Figures 1-4). These are in the same range as the concentrations found in sperm whales from off central California (Wolman and Wilson 1970), the North Atlantic (Taruski *et al.* 1975, Addison *et al.* 1972), and the Antarctic (Addison *et al.* 1972).

Conclusions

Sperm whales are unlikely to feed and have not been sighted near the major concentrations of contaminants in the SCB. The low levels found in this species are reflective of their pelagic habits.

MYSTICETES

Five species of baleen whales are common to the SCB and several others are infrequent visitors. The five most common species are minke whales, gray whales, humpback whales, blue whales, and fin whales. Three other species, the northern right whale, sei whale, and Bryde's whale infrequently occur in the SCB (Leatherwood *et al.* 1987) and are not considered here. Of these three only one stranding of Bryde's whale has been documented in the SCB from 1983-91. Bryde's whales and sei are hard to distinguish in the field and some past sightings did not always differentiate between the two (Leatherwood *et al.* 1987). Only three documented sightings of northern right whales have been made off southern California since 1982 including a sighting on 24 March 1992 off San Clemente Island (Carretta *et al.* 1994).

Gray whales

Background

Most gray whales migrate past southern California on route between their breeding grounds in Baja California, Mexico and their principal feeding grounds in the Bering and Chukchi Seas (Rice and Wolman 1971). Not all animals, however, complete the migration to these northern areas. Some gray whales feed in more southern waters and can be seen along the coasts of Mexico and California (Patten and Samaras 1977), Oregon (Sumich 1984), Washington (Flaherty 1983, Calambokidis *et al.* 1991, 1992), and British Columbia (Darling 1984) through the spring and summer. Some of these animals return in multiple years in the spring and summer to the same areas (Darling 1984, Calambokidis *et al.* 1992, 1993a).

The population size of the stock of gray whales along the eastern North Pacific has been estimated as just over 20,000 animals (Buckland *et al.* 1993a, IWC 1990, MMC 1993). The population has been steadily increasing at an estimated annual rate of about 3% (Buckland *et al.* 1993a, Reilly 1984, IWC 1990). The current abundance has reached the level estimated for the historical population and NMFS has proposed delisting the gray whale from the List of Endangered and Threatened Wildlife.

Gray whales feed primarily on organisms along the bottom throughout their range (Nerini 1984, Murison *et al.* 1984, Oliver and Slattery 1985, Weitkamp *et al.* 1992). A wide variety of prey have been documented for gray whales although the majority of the gray whale population feeds on ampeliscid amphipods in the Bering Sea (Nerini 1984).

Although few gray whales feed in the SCB, those that do are potentially vulnerable to contaminants due to their unique feeding behavior. Gray whales generally feed on organisms in the upper layers of soft substrates. The ingestion of some sediment material would potentially expose them to the elevated contaminant concentrations associated with sediments in many areas.

Observations in the SCB

Gray whales usually pass the SCB in December and January during the southbound migration and northbound in February and March with mothers and calves slightly later (Rice and Wolman 1971, Pike 1962). Migrating whales travel a variety of routes through the SCB and sightings are distributed both along the coast as well as outside the Channel Islands (Appendix figures). Leatherwood *et al.* (1987) reported that most whales take a route outside of the islands. The migration of gray whales through inside waters is the target of numerous whale watching operations from various harbors. Gray whales rarely feed in the SCB, with most animals traveling to feeding areas from northern California northward.

Gray whales were the most common large whale to wash up dead in the SCB with 53 strandings, 11 of them in Los Angeles County from 1983 to 1991. Heyning and Dahlheim (In press) summarized strandings and mortalities of gray whales along their entire range. Strandings along the SCB consisted of a high proportion of yearlings. The relatively higher numbers of strandings from the coast of California compared to other areas along the migration was attributed to the large amount of coastline with a high reporting frequency (Heyning and Dahlheim, In press).

Contaminant concentrations

Concentrations of PCBs and DDTs in gray whales found dead from locations along their migration route between Baja and Alaska have generally been low. Schafer *et al.* (1984) reported concentrations in various tissues of a gray whale from the SCB which had concentrations of 0.47 and 0.23 ppm wet weight in blubber. Similarly, Wolman and Wilson (1970) reported concentrations of less than 1 ppm total DDTs in blubber of 23 migrating gray whales collected off San Francisco, California. These concentrations are lower than most other marine mammals in the SCB (Figures 1-4). Concentrations of wide variety of contaminants were examined in stranded whales from California (San Francisco Bay), Washington, and Alaska (Varanasi *et al.* 1993). No significant differences were found in concentrations among the regions. Concentrations of PCBs and DDTs in blubber averaged 1.6 and 0.5 (n=22), respectively.

Conclusions

Gray whales rarely feed in the SCB and there is no evidence of elevated contaminant concentrations.

Humpback whales

Background

Humpback whales are distributed widely in the earth's oceans and are considered endangered due to heavy exploitation during whaling (Johnson and Wolman 1984). Commercial whaling of this species occurred in numerous areas throughout the North Pacific and continued in central California waters from stations in San Francisco Bay through 1965. Humpback whales migrate between low latitude breeding grounds and high latitude feeding areas. In the North Pacific, humpback whales primarily breed in the waters off Mexico, Hawaii, and the Bonin Islands.

Photographic identification techniques have revealed information on humpback whale stocks in the North Pacific. Humpback whales that feed along the California coast migrate to breeding grounds off Mexico (Calambokidis *et al.* 1989a), Costa Rica (Steiger *et al.* 1991) and Hawaii (Baker *et al.* 1986, Calambokidis *et al.* 1989a). Interchange of humpback whales between different feeding areas is more limited. The degree of interchange along the California coast varied as function of the distance between the areas (Calambokidis *et al.* 1989a, 1993b). Based on an absence of matches of individuals and DNA patterns, the humpback whales that feed along the California coast are distinct from those in Alaska (Baker *et al.* 1990, 1993, Calambokidis *et al.* 1993b).

The abundance of humpback whales in the North Pacific has not been determined. The official estimate of 1,200 for the North Pacific (NMFS 1987) is widely considered an underestimate because of the substantial numbers estimated on the Hawaiian breeding grounds alone (Darling and Morowitz 1986, Baker and Herman 1987, Mobley *et al.* 1993).

More precise abundance estimates have recently been made for humpback whales that occur off California. The population size of humpback whales that feed along the coast of California, Oregon, and Washington was estimated as 581 (CV 0.03) in 1992 from mark-recapture methods with identified individuals (Calambokidis *et al.* 1993b). Line transect estimates from ship surveys conducted along the California coast in 1991 yielded a similar estimate of 802 (CV 0.52) whales (Barlow 1993). Although most of these animals move to breeding grounds in the winter, aerial surveys conducted in the winter/spring off California yielded an estimate of 375 (CV 0.36) animals (Forney and Barlow, In press).

Observations in the SCB

Humpback whales have been sighted periodically throughout the SCB (Appendix Figures) (Leatherwood *et al.* 1987, Bonnell *et al.* 1980) including one off Los Angeles Harbor (Schulman 1984). Sightings in recent years have been more common. Calambokidis *et al.* (1993b) reported a large concentration of humpback whales in the Santa Barbara Channel in June and July of 1992 when 97 different individuals were identified photographically. Most of these animals moved north later in the summer (27 individuals were identified at various areas from Monterey Bay up to the California/Oregon border). Multiple sightings of the same animal during the season and inter-year re-sightings of some individuals indicate that some whales probably spend extended periods feeding in SCB over the years.

The apparent increase in sightings in recent years may, in part, reflect a recovery of humpback populations. With the end of commercial whaling, humpback whales populations are expected to be recovering from their depleted levels. Barlow (In press) reported that humpback whale sighting rates off California were significantly higher in 1991 than in 1979/1980.

A low proportion of humpback whales calves are seen off California (Steiger *et al.* 1989, Steiger and Calambokidis, In prep., Calambokidis *et al.* 1993b). Generally fewer than 5% of the animals seen off California are calves compared to 5-10% in other feeding areas. Even among known mature females seen in repeated years, the proportion with calves was low. The cause for this apparent low reproductive success has not been identified.

Two of the four strandings of humpback whales in California from 1983 to 1991 were in the SCB. There have been several more strandings since 1991, including 4 in 1993, one of them in SCB. Three of the four animals that stranded in 1993 were animals that had been documented feeding in the SCB in at least two previous years based on photographic identification using natural markings (Cascadia Research, Unpubl. data).

Humpback whales generally feed on both euphausiids and schooling fish (Nemoto 1970). Off central California, humpback whales have been observed primarily feeding on euphausiids (Kieckhefer 1992). Whaling data from central California indicated primary prey was euphausiids, anchovy and herring (Rice 1977, Calambokidis *et al.* 1989a). Humpbacks observed in the summer off southern California just north of Pt. Conception in 1988 and 1991 appeared to be feeding primarily on fish (Calambokidis, pers. obs.).

Contaminant levels

There are no contaminant data that we are aware of for humpback whales off California. Contaminant concentrations in humpback whales from other areas have generally been low. Peard and Calambokidis (1981) found low concentrations of total DDTs (0.2 and 0.09 ppm wet weight) and PCBs (0.09 and 0.13 ppm wet weight) in the blubber of two humpback whales found dead in southwestern Alaska. Taruski *et al.* (1975) found higher concentrations of total DDTs (1.4 to 23.1 ppm, wet weight) and PCBs (1.3 to 6.0 ppm, wet weight) in the blubber of four humpback whales from the North Atlantic.

Conclusions

Reported contaminant concentrations in humpback whales from other areas have generally been low but there is a lack of data on contaminant levels in humpback whales from southern California.

Blue whales

Background

Blue whales are distributed widely throughout the worlds oceans although their populations were severely depleted by commercial whaling in the 20th century (Mizroch *et al.* 1984a). Blue whale abundance in the North Pacific has been estimated as 1,600 (NMFS 1987, Gambell 1976) although this figure is based on sighting data from the 1960s. Two recent estimates of blue whale abundance off California gave different results: data from line-transect methods yielded an estimates of just over 2,000 whales (Barlow 1993), and mark-recapture calculations using identified animals yielded an estimate of 1,000 whales (Calambokidis *et al.* 1993b). Despite the disagreement in these estimates, they both indicate that a large blue whale population feeds in California waters and these waters may be one of the most densely used areas worldwide by this species since the onset of commercial whaling. Blue whales come to California waters to feed during the late spring, summer, and fall (Calambokidis *et al.* 1989, Dohl *et al.* 1983). Worldwide, blue whales feed almost exclusively on euphausiids (Nemoto 1970).

Occurrence in study area

Blue whales feed in SCB primarily in summer and fall, although some sightings have been made in all seasons (Bonnell *et al.* 1980, Leatherwood *et al.* 1987). Blue whales sighted from 1975 to 1985 occurred mostly outside the Channel Islands and in the western portion of the Santa Barbara Channel (Appendix Figures). In 1992, over 100 blue whales spent extended periods feeding in the Santa Barbara Channel and around San Miguel Island (Calambokidis *et al.* 1993b). A high proportion of the blue whales sighted in the systematic surveys of California waters in 1991 occurred off southern California (Barlow 1993). The locations of blue whale sightings indicate they generally feed away from areas of highest contaminant concentrations. Primary prey of blue whales in these waters has been krill, the dominant prey of blue whales worldwide, or pelagic red crab.

Blue whale populations appear to be increasing with significantly higher sighting rates off California in 1991 than in 1979-80 (Barlow, In press). There have been occasional strandings of blue whales in the SCB with four reported from 1983 to 1991 (two of them in Los Angeles County). At least three ship-strike related mortalities have been documented off southern California (Heyning, pers. comm.).

Contaminant concentrations

No contaminant data are available for blue whales from California. Levels found in the limited samples examined from other areas suggest blue whales generally have low concentrations, as would be expected from their feeding in more pelagic areas on euphausiids that would have low concentrations. Britt and Howard (1983) report concentrations of total DDTs of 0.1 ppm , wet weight and undetectable levels of PCBs in the liver of a juvenile blue whale that had been impaled on the bow of a freighter off Central America (Heyning (pers. comm.) thought this animals was struck off Ensenada, Mexico). Addison *et al.* (1972) reported concentrations of less than 1 ppm DDTs and PCBs in a marine oil from blue whales taken in Antarctic around 1950.

Conclusions

There are no contaminant data are available from SCB; blue whales in other areas have low concentrations of contaminants.

Minke whale

Background

Minke whales are one of the smallest of the baleen whales and occur in all oceans of the world (Stewart and Leatherwood 1985). In the northeast Pacific they range from the Chukchi Sea, Alaska to the Isla Revillagigedos off Baja California. Minke whales feed primarily on small schooling fish and euphausiids and to a lesser degree copepods (Nemoto 1970). Little is known about the migrations and movements of minke whales in the North Pacific, although individual whales seasonally use feeding grounds off California, Washington, and British Columbia primarily during the summer and fall (Dorsey *et al.* 1990).

One of the last of the whales to be exploited by commercial whaling, it is currently the target of renewed whaling efforts in the North Atlantic. Minke whale populations are not considered endangered or threatened though there are limited data on current abundance in many areas such as the North Pacific. Abundances of minke whales along the California coast has been estimated at 659 (CV 1.13) from vessel surveys during summer-fall, 1991 (Barlow 1993) and 71 (CV 0.61) from aerial surveys conducted winter-spring, 1991-92 (Forney and Barlow, In press).

Observations in the SCB

Minke whales are seen in SCB throughout the year (Leatherwood *et al.* 1987). Analysis of stranding data for 1983-91 show that four dead whales were reported in the SCB, including one in Los Angeles County. After gray whales, minke whales were the most common baleen whale sighted in the SCB during aerial and vessel surveys from 1975 to 1978 (Dohl *et al.* 1981). Locations of minke whale sightings show a more inshore distribution than most of the other large whales (Appendix Figures). Although the south side of the northern Channel Islands had the highest concentrations of sightings, there were also frequent sightings off Palos Verdes (Appendix Figures). Sightings occurred year-round, although they were most common in the spring and summer.

Contaminant concentrations

Surprisingly high concentrations of PCBs and DDTs were reported in an adult minke whale stranded in the SCB in 1977 (Schafer *et al.* 1984). Concentrations in blubber were 587 and 22.7 ppm, wet weight for total DDTs and PCBs, respectively. Concentrations of PCBs and total DDTs in other organs were also high with liver levels of 11.6 and 0.74 ppm total DDTs and PCBs, only a little lower than the concentrations found in the livers of SCB (Figures 1-4). These concentrations in blubber are the highest reported to date in a baleen whale (O'Shea and Brownell, In press). Concentrations of contaminants in minke whales from other areas have not been as high. Levels in a minke whale from Puget Sound, Washington were less than 1 ppm (Calambokidis *et al.* 1984). Levels in the blubber of a minke whale from the Gulf of St. Lawrence, Canada were 1.09 and 27.45 ppm, wet weight for total DDTs and PCBs, respectively (Sergeant 1980 in Gaskin 1982).

Conclusions

The absence of data makes evaluation of contaminant concentrations in this species difficult. The high concentrations in the single animal could reflect the piscivorous feeding of this animal and its use of inshore areas near sources of contamination.

Fin whale

Background

Fin whales are the second largest whale, after blue whales, and occur in latitudes above 20° in all oceans (Mizroch *et al.* 1984b). Fin whales occur on both the eastern and western sides of the North Pacific, which some consider to be separate stocks (Leatherwood *et al.* 1987). Like most other baleen whales, fin whales are thought to migrate between low latitude areas in winter months and higher latitude feeding areas in summer months. This pattern has not been well defined for specific groups of animals and there is evidence of potential year-round occurrence in some areas.

Fin whale populations also remain endangered as a result of depletion from commercial whaling. The abundance of fin whales in the waters off California out to 300 nmi in 1991 was 935 (Barlow 1993). Although there is little direct evidence, fin whale populations would be expected to be increasing as they recover from exploitation. Barlow (In press) found a more than two-fold higher abundance estimate and sighting rate of fin whales off California in 1991 compared to 1979-80, although the difference was not statistically significant.

Observations in the SCB

The distribution and prey of fin whales is unlikely to bring them into contact with high concentrations of PCBs and DDTs in the SCB. Fin whales were seen primarily outside the Channel Islands with relatively few sightings close to the coast (Appendix Figures). Although sightings occur in all seasons, numbers peak in summer with frequent sightings in a number of areas including the Santa Barbara Channel during this season (Leatherwood *et al.* 1987). Despite the year-round sightings, there is evidence that many of the animals are transitory to the area. Rice (1974) reported that eight fin whales marked off southern California in the winter were recovered from central California to the Gulf of Alaska in summer. Abundance estimates of fin whales in summer and fall (Barlow 1993) were much higher than those for winter and spring (Forney and Barlow In press).

Unlike the more specialized blue whale, fin whales feed on euphausiids, copepods, and small fish (Nemoto 1970). Despite the varied diet of fin whales in other areas, most animals caught during whaling off California had euphausiids in their stomachs and only 7% having anchovies (Rice 1977).

Contaminant concentrations

There are no contaminant data for fin whales off California. Borrell (1993) found fin and sei whales have low concentrations of PCBs and DDTs compared to other odontocetes from the Northeast Atlantic (Iceland and Faroes).

Conclusions

Despite the absence of contaminant data, it is likely that fin whales are not exposed to high concentrations of contaminants in the SCB because of their offshore distribution and because they feed primarily on euphausiids.

PINNIPEDS AND SEA OTTER

California sea lion

Background

Three subspecies of the California sea lion, all in the Pacific are recognized (Scheffer 1958). These include: 1) *Zalophus californianus japonicus* that inhabited the Sea of Japan and may be extinct, 2) *Z.c. wollebaeki* that breed on the Galapagos Islands, and 3) *Z.c. californianus* that breeds off California and Mexico and is discussed in this report. This subspecies breeds on islands from the Southern California Bight (SCB) southward through Baja California and in the Gulf of California, Mexico. Adult males range from as far south as southern mainland Mexico (Gallo and Solorzano 1991, Gallo and Ortega 1986) and as far north as British Columbia (Bigg 1988). It is primarily the males that make a seasonal northern migration to feeding areas off northern California, Oregon, Washington, and British Columbia.

California sea lion populations have been recovering from commercial sealing, live captures, and sport killing which occurred at different levels from the 1800s through the 1950's (Stewart *et al.* 1993). More data are available on the status of California sea lions in U.S. waters than in other areas.

Observations in the SCB

California sea lions occur year-round in the SCB, despite the migration of some portion of the population outside this area. They are widely distributed at sea within the SCB (Appendix Figures). Centers of concentration vary by season with highest densities occurring around the northern Channel Islands and Santa Barbara Island in summer and fall and around Santa Catalina and San Clemente Islands in winter and spring (Bonnell and Ford 1987).

California sea lion breeding populations in the SCB have increased dramatically in the last 50 years. From a population of only a few thousand in the 1930s, the U.S. population has increased to approximately 87,000 animals by 1987 (Boveng 1988b) and 111,000 by 1990 (Lowry *et al.* 1992). The number of California sea lion (based on pup counts) breeding in U.S. waters increased at an annual rate of 10.2% from 1983 to 1990, after a high apparent mortality as a likely result of the 1982-1983 El Niño (Lowry *et al.* 1992).

A number of studies have examined the prey of California sea lions in the SCB, most of these were based on remains collected on the Channel Islands. Primary prey of California sea lions in spring and summer on San Miguel Island were Pacific whiting, market squid, rockfish, jack mackerel, and northern anchovy (Antonelis *et al.* 1984). Similar primary prey were documented at San Nicolas and San Clemente Islands in samples taken during different seasons from 1981-86, though dramatic annual and seasonal variations were found (Lowry *et al.* 1990, 1991). Direct observations of California sea lions feeding were made in mainland coastal waters from Sealab II and revealed predation on anchovy, jack mackerel, white croaker, and squid (Clarke *et al.* 1967).

Large numbers of California sea lion premature pups in the Channel Islands were first noted in the late 1960s. In 1969 and 1970, 135 and 422 premature pups were seen at San Nicolas Island out of just over 2,700 born each year (Odell 1970). On San Miguel Island, the minimum number of premature pups from 1970 to 1975 ranged from 242 in 1970 to 1,002 in 1972 (Gilmartin *et al.* 1976). The rates of premature births on San Miguel reached 20% of pups born in 1972 (Gilmartin *et al.* 1976), but rates have subsequently decreased. Francis and Heath (1991) reported increases in mortality of California sea lion pups and the incidence of premature births on San Nicolas Island during 1983 and 1984, apparently related to El Niño.

Observations for premature California sea lion pups prior to the late 1960s and in Mexican waters were more limited. Premature pups had been occasionally encountered from 1948 to the 1960s in the Channel Islands (Odell 1970). Similarly small numbers of premature pups were also seen at breeding locations in Mexico (Brownell and Le Boeuf 1971, Le Boeuf and Bonnell 1971). The premature pups were generally born alive as early as February on San Miguel Island (DeLong *et al.* 1973) and as early as January on San Nicholas Island (Odell 1970). The pups lacked motor coordination and died from a few hours to a few days after birth (DeLong *et al.* 1973).

California sea lions were the most common marine mammal reported to the NMFS stranding network in the SCB from 1982-1991 (Table 2 and 3). These included frequent strandings (333) in Los Angeles County (Table 2). The number of strandings of California sea lions in the SCB varied dramatically by year with the highest number of strandings in 1983 (the first year of complete data), 1990, and 1991 (Table 3).

Analysis of the NMFS stranding data provided information on the age class and sex of California sea lions stranding in the SCB. A majority (57%) of the 188 California sea lions stranded in Los Angeles County with age class information were thought to be adults. The rest of the animals with age class information ranged from presumed pups to juvenile and subadult animals. Equal numbers (36 each) of males and females were reported for Los Angeles County. A slightly higher proportion of males (59%) than females (41%) were reported stranded for the SCB as a whole. These data indicate that both sexes and a variety of age classes utilize the waters in the vicinity of the Los Angeles County coastline where highest concentrations of PCBs and DDTs have been found in sediment and other biota in the SCB (Mearns *et al.* 1991).

Large numbers of stranded juvenile and adult California sea lions have been documented along the coast of central and northern California and Oregon linked to renal disease suspected to be from Leptospirosis in 1984 and 1988 (Gerber *et al.* 1993, Hodder *et al.* 1992). Several thousand California sea lions have been killed annually incidental to set net fisheries off California in the 1980s and early 1990s (Hanan and Diamond 1989, Hanan *et al.* 1988, Miller *et al.* 1983, Perkins *et al.* 1992, Julian 1993).

Recovery of tagged animals in the SCB reported to NMFS demonstrates that animals that strand in Los Angeles County come from a number of breeding islands including San Miguel Island. Of the seven tagged California sea lions recovered from Los Angeles County, one was tagged on San Miguel, two each were tagged on San Nicolas and Santa Barbara Islands, one was a rehabilitated animal, and one was a green tag potentially tagged in Moro Bay. Seven California sea lions tagged at San Miguel Island (with yellow tags) were reported recovered somewhere in California to NMFS, one was from Los Angeles County, two from Ventura County, one from Orange County, one from Santa Barbara County, and two from central California.

Contaminant concentrations

Concentrations of PCBs and DDT compounds in California sea lions from the SCB have been examined by a number of authors (Table 8). Le Boeuf and Bonnell (1971) first reported extremely high concentrations DDT compounds in California sea lions from southern and central California. Concentrations of total DDT in blubber averaged between 689 and 1006 ppm (wet weight) for three different groups of animals collected in different ways (healthy-killed, sick-killed, and fresh dead). DeLong *et al.* (1973) and Gilmartin *et al.* (1976) reported significantly higher concentrations of PCBs and DDTs in blubber and liver of premature partus females and pups compared to full-term animals from San Miguel Island in the early 1970s.

Britt and Howard (1983) reported concentrations of PCBs and DDTs in the liver of 64 California sea lions that stranded along the coast of Los Angeles County between 1970 and 1981 (Table 8). Average concentrations of total DDT and PCBs in liver were lowest in adult females (32 and 8 ppm) and highest in adult males (86 and 17 ppm). These concentrations of DDT are higher than found in the liver of any other pinniped worldwide that were reviewed in Wagemann and Muir (1984). The concentrations of both PCBs and DDTs in the liver of these stranded animals (Figures 3 and 4) were also higher than found in even premature partus females California sea lions from San Miguel Island (DeLong *et al.* 1973, Gilmartin *et al.* 1976) or livers of California sea lions from the Oregon coast (Buhler *et al.* 1975). Britt and Howard (1983) concluded these elevated concentrations were likely the result of two factors: 1) the emaciated state of some of the animals causing mobilization of contaminants from the blubber to the liver, and 2) the proximity of these animals to the high concentrations of contaminants off the Palos Verdes Peninsula. Bacon *et al.* (1992) found highest concentrations of DDTs in milk from a California sea lion from San Nicolas Island compared to other pinnipeds from the Arctic, Antarctic, Australia, and central California. PCBs in California sea lion milk from San Nicolas Island were second highest after samples from elephant seals from central California (Bacon *et al.* 1992).

Conclusions

High concentrations of DDTs and PCBs, compared to other species from other parts of the world, have been documented in California sea lions. Premature parturient females and their pups had significantly higher concentrations of these contaminants than full-term pups.

Northern sea lion

Background

The northern (or Steller) sea lion ranges from Japan along the Pacific Rim to southern California with most large rookeries in the Gulf of Alaska and the Aleutian Islands (Loughlin *et al.* 1984, 1987). Small rookeries can be found in northern California at Cape St. George, and on Southeast Farallon Island and Año Nuevo Island in central California (Loughlin *et al.* 1992a). Until recently, northern sea lions also bred on San Miguel Island in the SCB (Bartholomew 1967, Loughlin *et al.* 1992a).

Although this species is not considered migratory (Loughlin *et al.* 1987), some animals may travel long distances seasonally (Hoover 1988). Adult males in the southeastern part of their range move north after the breeding season and then return to the rookeries in the early spring (Kenyon and Rice 1961, Mate 1973). Adult females and juveniles apparently stay in the general area of the rookeries during the summer (Antonelis and Fiscus 1980) but can range up to 300 km offshore in the winter (Loughlin *et al.* 1992b). Subadult sea lions have been recorded moving up to 1500 km in Alaska (Calkins and Pitcher 1982).

The northern sea lion feeds primarily on fish and cephalopods, with prey varying by area and season (Loughlin *et al.* 1992a). Cephalopods form a major part of the diet in the Gulf of Alaska, supplemented by shelled molluscs and crustaceans. Pollock has increased in the diet from the late 1950's to the late 1970's in possible response to increased abundance of this prey. Prey consumed include: capelin, greenlings, herring, lamprey, Pacific cod, rockfish, salmon, sandlance, sculpin, smooth lumpsucker, walleye pollock, Pacific whiting, and other fish. Prey consumed off California include rockfish, sanddab, and turbot (Fiscus and Baines 1966, Antonelis and Fiscus 1980, Jones 1981).

Observations in the SCB

In the late 1920's, the northern sea lion was considered the most abundant pinniped in southern California (Bartholomew 1967). A population of 2,000 animals bred on San Miguel Island in the 1930's and declined to less than 100 animals by 1958 (Bartholomew 1967). In 1964, 68 animals were counted on San Miguel including 7 pups (Odell 1971). From 1969 through the early 1970's, pup production on San Miguel was around 10 pups per year (DeLong 1975). In 1975, a maximum 19 animals including 3 pups were counted from the air (Bonnell *et al.* 1980) and by 1982, only two pups were born on this island (Reeves *et al.* 1992). Most recently, Loughlin *et al.* (1992b) reported that northern sea lions no longer hauled out at San Miguel Island. Northern sea lions were rarely seen at sea in the SCB during surveys in the 1970s (Bonnell *et al.* 1980) and there were no strandings reported to NMFS for this species in the SCB from 1983-91.

The decline observed in the SCB is not a geographically isolated event. Overall in California, total counts of northern sea lions have dropped from 6,000-7,000 in the 1960's, to 2,500-3,000 in 1982, to about 2,000 in 1989 (Loughlin *et al.* 1984, 1992b). Worldwide in 1989, the northern sea lion population was estimated at 116,000 individuals, representing a decrease of as much as 48% from 1961 levels (Loughlin *et al.* 1992b). Le Boeuf and Bonnell (1980) argued that the northern California populations of northern sea lions were relatively stable compared to the decreasing southern California population. However, declines in the central and northern populations are now also apparent. At Año Nuevo Island, maximum counts varied between 800 to 2600 from 1961-1976 (Le Boeuf and Bonnell 1980) but declined to 422 individuals by 1990

(Loughlin *et al.* 1992b). At the Farallon Islands, the breeding population was described as stable over the late 1960's at approximately 130 animals including about 27 pups per year (Le Boeuf and Bonnell 1980). This population appears to have declined since the 1960s; Loughlin *et al.* (1992b) reported a 1990 count for the Farallones of 97 animals including 3 pups.

Contaminant concentrations

There are no data on contaminant concentrations in northern sea lions from the SCB. Huber *et al.* (1984) reported concentrations of DDE of 25 to 490 ppm, and PCBs of 15 to 94 ppm, lipid weight blubber of seven premature northern sea lion pups from the Farallon Islands off central California.

Conclusions

Northern sea lions no longer breed in the SCB and have stopped using historic haul out sites on San Miguel Island. Most of the decline in this population occurred prior to the late 1950s. Population declines have occurred throughout their range though the cause of decline in any region remains poorly understood. There are no data on contaminant levels for these animals in southern California.

Harbor seal

Background

Harbor seals are found across the temperate and subarctic latitudes of the Northern Hemisphere on the coastlines of Japan, Russia, the United States, Mexico, Canada, Iceland, the United Kingdom, northern Europe and Scandinavia (Reeves *et al.* 1992). *Phoca vitulina richardsi,* the harbor seal of the Eastern Pacific, is the subspecies found along the California coastline. Total world population of harbor seals is estimated at around 4-500,000 (Reeves *et al.* 1992). Minimum population size for California in 1991 was 23,000 (Hanan *et al.* 1992).

Harbor seal populations in many areas of the eastern North Pacific have generally increased over the last 20-30 years due to the end of bounties and legal protection by the Marine Mammal Protection Act of 1972. During the 1970s and 1980s, annual increases in abundance of 5-20% have been reported for harbor seals in California (Boveng 1988a), Oregon (Harvey 1987), Washington (Calambokidis *et al.* 1985, Jeffries 1986), and British Columbia (Olesiuk *et al.* 1990). There has been an unexplained decline in the number of harbor seals at some sites in the Gulf of Alaska (Pitcher 1990).

Harbor seals are opportunistic feeders and have been documented to feed on a wide variety of fish, cephalopods, and invertebrates. Numerous studies have each documented more than a dozen species of fish eaten by harbor seals in different regions including off California (Stewart and Yochem 1985), Oregon (Brown and Mate 1983), Washington (Calambokidis *et al.* 1978), British Columbia (Olesiuk 1993), and Alaska (Pitcher 1980). Principal prey included Pacific whiting, plainfin midshipman, walleye pollock, capelin, sandlance, tomcod, staghorn sculpin, starry flounder, herring, rockfish, salmon, squid, octopus, and crustaceans.

Both site fidelity and long distance movements have been documented in harbor seals (Reeves *et al.* 1992). Long distance movements, sometimes greater than 500 km have been documented in radio-tagged harbor seals in several areas of the North Pacific (Brown and Mate 1983, Pitcher and McAllister 1981, Jeffries 1986, Huber *et al.* 1993). Evidence of site fidelity has also been seen in some of these radio-telemetry studies as well as studies based on differences in contaminant concentrations (Calambokidis *et al.* 1985).

Observations in the SCB

Counts of both the entire California mainland and the Channel Islands have shown a pattern of rapid increase through the early 1980s followed by a slower rate of increase or no change from 1982 to 1993. Boveng (1988a) reported that mainland California harbor seal populations grew 16% per year from 1965 to 1982, although this increase may have been due to differences in methodologies over the years. Since 1982, when standard annual surveys were started, mainland harbor seal populations have increased significantly ($p<0.01$) at an annual rate of 4% (regression using log transformed counts from Hanan and Beeson 1994). Stewart *et al.* (1988) reported an annual increase of 22% for San Miguel Island from 1958 through 1976, which slowed to about 5% from 1976 through 1986. Counts of all the Channel Islands conducted annually using similar methods from 1983 to 1993 showed no significant ($p>0.05$) trend (regression analysis using data from Hanan and Beeson 1994).

Stewart *et al.* (1993) present data on counts of harbor seals on all eight Channel Islands from the late 1950s through the mid-1980s. Numbers of seals using the three islands closest to Palos Verses (Santa Catalina, San Clemente, and Santa Barbara) showed no clear trend while counts of seals at the five other islands showed clear increases in seal numbers.

We tested for increases in harbor seal numbers at the two haul-out sites closest to Palos Verdes (Mugu Lagoon and Santa Catalina Island) using data for 1982 to 1993 reported by Hanan and Beeson (1994) (Figure 1). Numbers of harbor seals increased significantly ($p<0.05$) at an annual rate of 6% at Mugu Lagoon for 1982-93 and at an annual rate of 13% at Santa Catalina Island.

The degree to which harbor seals utilizing mainland areas in the SCB are separate from those on the Channel Islands is not clear. This is certainly within the range of movements described for harbor seals in other areas (se above). Seals tagged on San Nicolas and San Miguel Islands have been sighted on the mainland and have moved between these islands (Yochem and Stewart 1985, Stewart and Yochem 1983); however, no shifts in the breeding location of individuals between the Channel Islands and mainland have been recorded (Boveng 1988a). Additional unpublished data on harbor seal movements from tagging studies also indicate movements of some animals, but also fidelity to sites (B. Stewart, pers comm. and D. Hanan, pers. comm.).

Harbor seals were infrequently observed at sea during aerial and ship transects in the 1970s with over 50% of the at sea sightings were within 10 km of the northern Channel Islands (Bonnell *et* *al.* 1980, Appendix Figures). In California waters, harbor seals have seldom been reported from water deeper than 90 m (Antonelis and Fiscus 1980). Harbor seals were also seen at low densities throughout the Santa Barbara Channel, over the Santa Rosa-Cortes Ridge, over the San Pedro Basin, and off the mainland near the Palos Verdes Peninsula (Bonnell *et al.* 1980).

Harbor seals are the second most common pinniped, after California sea lions, reported stranded to NMFS in the SCB (Table 2). Strandings of harbor seals occur in all counties of the SCB with one third of the strandings coming from Los Angeles County (Table 2). Strandings in Los Angeles County consisted of animals of both sexes with similar numbers classified as pups, subadults (including yearlings), and adults. Premature pups were infrequently reported as strandings, with only two clear reports apparent in the stranding records (in Los Angeles and Santa Barbara Counties). Schroeder *et al.* (1973) reported a variety of conditions in 13 harbor seals that stranded in Los Angeles County in the early 1970s including: heartworms, pneumonia, inanition, parasitic ulcerative gastritis, parasitic pneumonia, and gunshot. No links were made between these conditions and contaminants.

Observations of harbor seals have been made at the Mugu Lagoon harbor seal haul-out area for a number of years by base personnel (T. Keenan, pers. comm.). At this site, only two premature pups have been seen in the last 5 years, both in December 1992. Typically each year about 25 pups are born at this site (T. Keenan, pers. comm.).

The prey of harbor seals utilizing mainland sites in the SCB, including Mugu Lagoon, the closest site to Palos Verdes, have recently been examined based on more than 900 scats collected at four sites from 1988-93 (Beeson 1993, M.J. Beeson, pers. comm.). Primary prey recorded included plainfin and specklefin midshipman, various flatfish, rockfish, and cephalopods (squid and octopus). A number of other prey types were also identified including cusk eels, whiting, white croaker, surfperches, northern anchovy, California lizardfish, and blacksmith. Prey eaten by harbor seals from San Miguel Island include plainfin midshipman, pileperch, and octopus (Antonelis and Fiscus 1980, Hoover 1988) and at San Nicolas Island, the most common species (in order), were rockfish, spotted cusk-eel, plainfin midshipman, shiner surfperch, octopus, dover sole and rock sole (Stewart and Yochem 1985).

Contaminant concentrations

Only limited data on concentrations of PCBs and DDTs are available for harbor seals in southern California (Table 9) and these suggest fairly high concentrations compared to other species and other areas. Anas (1974) reported concentrations of 2,200 ppm (wet weight) total DDT and 572 ppm PCBs in the blubber of an adult male harbor seal from San Miguel Island in 1971. This concentration is higher than for most species in the SCB and is only comparable to values found in some California sea lions, bottlenose dolphins, and common dolphins from the SCB (Figures 1 and 2). Four other harbor seals from San Miguel Island were also analyzed by Anas (1974), but only a combined PCB+DDT value reported. These other four animals had combined PCB+DDT concentrations in blubber that ranged from 381 to 518 ppm. The PCB+DDT concentrations compared by Anas (1974) were highest in the SCB and Puget Sound, Washington and lowest in Oregon and Alaska.

Britt and Howard (1983) reported concentrations of DDTs and PCBs in the liver of four harbor seal sub-adults from Los Angeles County collected from 1976 to 1980. Concentrations ranged from 0.18 to 14 ppm PCBs (geometric mean=5.4) and 8.7 to 101 ppm total DDT (geometric mean=23.3). Concentrations of PCBs and DDTs in harbor seal liver from the SCB reported in Britt and Howard (1983) are generally higher than found in harbor seals from other areas along the U.S. west coast including central and northern California (Shaw 1971, Risebrough 1978), and Washington State (Arndt 1973).

The mean PCB concentrations for harbor seals from the SCB were similar to those reported for 1-24 m old male and female California sea lions (5.4 vs. 5.6 ppm) and generally higher than those reported for elephant seals and northern fur seals (2.1 and 4.6 ppm, respectively) from the same area, though the differences were not significant (ANOVA, p>0.05). Total DDT concentrations in harbor seals were higher than the other three species (23.3 ppm vs 10.8 to 18.2) though again these differences were not significant (ANOVA, p>0.05). The total DDT concentrations in liver were higher than reported for any other pinniped in the extensive review by Wagemann and Muir (1984). Only premature partus adult female California sea lions from San Miguel Island (DeLong *et al.* 1973, Gilmartin *et al.* 1976) had comparable concentrations of total DDT in their tissues. Concentrations of PCBs in the livers of harbor seals from Los Angeles County, were high but not among the highest reported in pinnipeds from other parts of the world (Wagemann and Muir 1984). PCBs were similar in concentration to those found in the adult female California sea lions giving birth prematurely (DeLong *et al.* 1973, Gilmartin *et al.* 1976).

Conclusions

The small sample of harbor seals tested for PCBs and DDTs revealed relatively high concentrations similar to those in California sea lions.

Northern elephant seal

Background

Northern elephant seals breed on islands off the coast of Mexico, in southern California (Channel Islands), and in central California (Año Nuevo Island and mainland, southeast Farallon Islands, and Point Reyes). During the non breeding season, they range along the coast of Oregon, Washington and Alaska, as far north as the Gulf of Alaska and west to the Aleutian Islands (Condit and Le Boeuf 1984, DeLong and Stewart 1991, Reeves *et al.* 1992). Adult males and females make two foraging migrations each year to separate areas of the north Pacific with males traveling to the Gulf of Alaska and along the Aleutian Islands and females visiting areas farther south offshore of Washington and Oregon (Stewart and DeLong 1990). The distribution of young elephant seals at sea is relatively unknown (Reeves *et al.* 1992).

The world population of northern elephant seals has been estimated at just over 100,000 in 1991 (Reeves *et al.* 1992, Stewart and Huber 1993). Total pups born at California rookeries in that year exceeded 21,000, 85% of which were born on San Nicolas and San Miguel Islands (Barlow *et al.* 1993b). Cooper and Stewart (1983) estimated growth of northern elephant seal populations at 14-53% percent annually, averaging 14.5% across the rookeries surveyed in California from approximately 1960 through 1980. They estimated the Mexican populations grew at 8.3% annually from 1965-1977.

Northern elephant seals primarily eat vertically migrating epi- and meso-pelagic squid, in addition to Pacific whiting, cusk-eels, rockfish, sharks, rays, and ratfish (Condit and Le Boeuf 1984, DeLong and Stewart 1991, Sinclair 1994). Recent data on adult males and females show they feed in deep waters seaward of the continental slope (Le Boeuf *et al.* 1985, 1986, Reeves *et al.* 1992).

Observations in the SCB

The majority of the northern elephant seal population breeds in the SCB. In general, elephant seals were rarely seen at sea. Elephant seals were more often seen inshore in the spring as compared to the rest of the year when they were widely scattered throughout the SCB (Bonnell *et al.* 1980). They were consistently observed in the vicinity of Santa Monica Bay and the San Clemente Escarpment especially during the winter and spring (Appendix Figures). It is probable that they were feeding in these areas, but Bonnell *et al.* (1980) also noted that the high frequency of sightings in the southeastern SCB (near San Clemente Island) may reflect northward movement of the Mexican population. Juvenile northern elephant seals that stranded in the SCB from 1969 to 1983 had been feeding on a variety of fish, cephalopods, and crustaceans, predominantly squid, spotted cusk-eel, and Pacific whiting (Sinclair 1994).

A total of 56 strandings of northern elephant seals were reported to NMFS and occurred in all counties in the SCB, including 12 in Los Angeles County (Table 2). More than half the strandings in the SCB occurred in 1983 and 1991 (Table 3). Stranded animals in Los Angeles County included both males and females and primarily consisted of adults or subadults with no pups or yearlings.

Although a large portion of the adult population is known to feed in deeper waters, it is unclear to what extent some portion of the northern elephant seal population forage in the SCB. As noted, the majority of the population breeds in the Bight and these animals in addition to those from Mexico pass through this area in migrations to other foraging grounds.

Contaminant concentrations

Contaminant concentrations in elephant seals from California waters have been reported by several researchers (Table 10). Although these provide only limited insight into geographic patterns of contamination they do suggest that concentrations in northern elephant seals are lower than in some other pinniped species in the SCB (Figures 1-4). This would be expected given the evidence of feeding in offshore waters outside the SCB discussed above.

Britt and Howard (1983) reported concentrations of total DDTs from 0.3 to 51.2 ppm (geometric mean=10.8) and PCBs from 0 to 9.0 ppm (geometric mean=2.1) wet weight in liver of seven pup and sub-adult northern elephant seals collected from 1974 to 1981 in Los Angeles County. These concentrations tended to be lower than found in other pinnipeds (including California sea lions) collected in this area during the same time period (Britt and Howard 1983), although the differences were not statistically significant.

Schafer *et al.* (1984) reported concentrations of DDTs and PCBs in various tissues of four 6-year-old northern elephant seals killed on San Nicholas Island, off southern California, in 1983 and 1984. The concentrations in liver were lower than reported by Britt and Howard (1983) and ranged between 0.06 and 0.96 ppm for total DDT and 0.004 and 0.44 ppm for PCBs. Concentrations in blubber were low compared to some other southern California marine mammals and ranged from 2.76 to 11 ppm total DDT and 0.26 to 4.04 ppm PCBs.

Contaminant concentrations have also been examined in northern elephant seals collected farther north in central and northern California in spring 1992 (Newman *et al.* 1993, pers. comm.). Yearling elephant seals had geometric mean concentrations of 2.8, 4.2, and 3.9 ppm total DDTs and 0.62, 0.8, and 1.5 ppm PCBs for healthy early molters (n=8), healthy late molters (n=5), and skin disease animals (n=6), respectively. Milk from elephant seals from central California had the second highest (after a California sea lion from the SCB) concentrations of DDT compounds and the highest concentrations of PCBs compared to the milk from other pinnipeds from the Arctic, Antarctic, Australia, and California (Bacon *et al.* 1992).

Conclusions

Concentrations of PCBs and DDTs were lower in northern elephant seals than in other SCB pinnipeds. Their general offshore feeding patterns would be expected to take them away from areas of contaminant concentrations, even though sightings made off Palos Verdes and Santa Monica Bay suggest some animals might be feeding in contaminated areas.

Northern fur seal

Background

Northern fur seals breed on Robben Island, Japan, the Kuril and Commander Islands, Russia, the Pribilof Islands and Bogoslof Island, Alaska, and San Miguel Island, California. Females and juveniles from the primary breeding grounds in Alaska migrate south along the west coast of the United States after the summer breeding season to areas off the coast of British Columbia, Washington, Oregon, and California.

The population of northern fur seals in the Pribilofs is presently estimated at 982,000 (Loughlin *et al.*, In prep.) with an additional 1473 on Bogoslof Island (Baker and Kiyota 1992). On San Miguel Island, 1771 pups were counted in 1990 (DeLong and Melin 1992). Declines in the population of this species in the last 30 years have been attributed to the long-term effects of a kill of young females in the 1950s and 1960s (York and Hartley 1981) and to entanglement in discarded pieces of nets (Fowler 1982).

In the winter and spring, large numbers of fur seals, primarily migrants from the Bering Sea populations feed along the California coast beyond the edge of the continental shelf (Fiscus and

Kajimura 1969, Bonnell *et al.* 1980). Northern fur seals have been documented feeding on 53 species of fish and 10 species of squid (Kajimura 1984). Primary prey in northern waters was herring, capelin, sandlance, sablefish and pollock (Kajimura 1984). Off California, primary prey were anchovy, whiting, saury, rockfish, and jack mackerel (Kajimura 1984). Predominant prey of fur seals examined on San Miguel Island in the SCB were whiting, Californian lanternfish, several species of squids, jack mackerel, and anchovy (DeLong and Antonelis 1991, Antonelis *et al.* 1990).

Observations in the SCB

Within the SCB, this species is found primarily along the Santa Rosa Cortes Ridge and near the Tanner Bank (Bonnell *et al.* 1980). Northern fur seals radio-tagged in the summer on San Miguel Island, the sole breeding ground in California, foraged northwest of the island in oceanic waters over the continental slope (Antonelis *et al.* 1990). Sightings of California sea lions in the SCB were distributed offshore with no sightings in the areas of highest contaminant concentrations (Appendix Figures). Strandings in the SCB have been infrequent with only three reported for 1983-91, one within Los Angeles County (Table 2).

The population on San Miguel Island grew rapidly between 1969 and 1978 with 34% and 46% increases in pups born at Castle Rock and Adams Cove, respectively. There has been no evidence of a decline in this population apart from a drop following the 1982-83 El Niño (DeLong and Antonelis 1991). The growth rate of the San Miguel colony is in part, due to emigration from the Pribilof Islands (DeLong 1982).

Contaminant concentrations

Concentrations of PCBs and DDTs in liver of four sub-adult northern fur seals found dead in Los Angeles County in 1979 and 1980 (Table 10) were reported by Britt and Howard (1983). Concentrations of total DDT in liver ranged from 4.81 to 15.2 ppm (geometric mean= 10.6) and PCBs from 1.9 to 9.7 ppm (geometric mean=4.63). These concentrations were generally lower than California sea lions found dead in the same area during the same period (Figures 3 and 4), but the differences were not significant (t-test, $p>0.05$).

Conclusions

Northern fur seals generally fed in offshore waters away from areas of contamination. The limited contaminant data show levels that appear to be lower than some of the other pinniped species.

Sea otters

Background

The historic range of the sea otter encompassed the temperate coastal waters of the North Pacific Rim from northern Japan, through Russia, Alaska, British Columbia, Washington, and Oregon to California. Two centuries of commercial exploitation reduced the range to small scattered groups in Russia, the Aleutian Islands, the Alaska Peninsula, the Kodiak Archipelago, Prince William Sound, and California (Hoover 1988). Attempts to reestablish populations by translocation on the Pribilof Islands, in Southeast Alaska, British Columbia, Washington, and Oregon have been variably successful, with apparent failure in Oregon and on the Pribilof Islands (Jameson *et al.* 1982, 1986). The success of a recent translocation to San Nicolas Island, California is still undetermined (Rathbun *et al.* 1989, Riedman and Estes 1990).

Sea otter home ranges consist of heavily used areas connected by travel corridors (Riedman and Estes 1990). While movements of >10 km were rare (Ralls *et al.* 1988), males in California moved seasonally an average 80 km (maximum 150 km) from female areas to peripheral male groups (Jameson 1989). Females tend to have smaller lifetime home ranges than males, an average 18 km, and move maximum distances of 110 km (Jameson, pers. comm. in Riedman and Estes 1990). Juveniles can disperse up to 187 km from their natal site (Jameson 1989) with males tending to travel farther than females (Riedman and Estes 1990). Observations of movements in the Aleutian Islands (Lensink 1962, Kenyon 1969) suggest otters can move rapidly across expanses of deep water. Adult otters returning to their capture site after translocation to San Nicolas Island traveled an average 335 km across the open ocean (Jameson and Hatfield 1989). The occasional otter has been seen as far south as Baja California including individuals sighted around the Channel Islands, in Santa Monica Bay, and Los Angeles Harbor (Leatherwood *et al.* 1978).

The diet of the sea otter varies considerably among individuals and in California consists mainly of abalone, red sea urchins, and rock crabs (Riedman and Estes 1990). Otters in this region also consume kelp crabs, various species of clams, turban snails, mussels, octopus, sea stars, fat innkeeper worms, chitons, and seabirds (Estes *et al.* 1981, Riedman and Estes 1990). Predation on fish is rare in contrast to sea otters in Russia and Alaska where epibenthic fish were also commonly consumed.

Observations in the SCB

Prior to exploitation, as many as 16,000-20,000 otters may have lived in California and Baja California, with highest abundance in the Channel Islands, northern, and central California (Kenyon 1969). Recent (1989) counts showed 1,864 otters in central and northern California (Jameson and Estes unpubl. data in Riedman and Estes 1990) and an additional 22 on San Nicolas Island (Rathbun *et al.* 1989).

Outside of the 1987 translocation to San Nicolas Island, otters have not otherwise inhabited the SCB this century. Otters are capable of traveling long distances, and have occasionally been seen in the SCB. However, the southernmost extension of their range, is approximately 50 km north of Pt. Conception, the northernmost point of the SCB. Lifetime home ranges for female and male otters of 18 and 80 km, respectively, place all but a small fraction of the population out of reach of the SCB and clearly beyond the coastal waters in the central SCB.

The worldwide population of sea otters, now estimated at over 150,000 individuals (Riedman and Estes 1990), has increased rangewide from 1911 estimates as low as 1,000-2,000 individuals

(Kenyon 1969). However, the central California population of sea otters has increased during this period at about one-fourth the rate of similarly open-ended populations in Washington, British Columbia and Alaska (Estes 1990).

Contaminant concentrations

Shaw (1971) reported concentrations of DDT compounds in sea otters from the central California coast collected in 1969 and 1970. Concentrations of total DDT in fat averaged 11.1 ppm and are lower than found in most other marine mammals from California (Table 10, Figures 1-4).

Conclusions

Other than a small number of sea otters translocated to San Nicolas Island, sea otters rarely occur in the SCB.

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Table 1. Marine mammal species occurring in the SCB (based on Leatherwood *et al.* 1987 and Dohl *et al.* 1981). Those marked with "X" are those considered in detail in this report. Other species are uncommon to area.

Species	Scientific name	Included
Seals and sea lions	**Pinnipedia**	
Harbor seal	*Phoca vitulina*	X
Northern elephant seal	*Mirounga angustirostris*	X
California sea lion	*Zalophus californianus*	X
Northern or Steller sea lion	*Eumetopias jubatus*	X
Northern fur seal	*Callorhinus ursinus*	X
Guatalupe fur seal	*Arctocephalus townsendi*	
Mustelids	**Order Carnivora, family Mustelidae**	
Sea otter	*Enhydra lutris*	X
Toothed whales, dolphins and porpoises	**Cetacea, suborder Odontoceti**	
Harbor porpoise	*Phocoena phocoena*	X
Dall's porpoise	*Phocoenoides dalli*	X
Common dolphin	*Delphinus delphis*	X
Bottlenose dolphin	*Tursiops truncatus*	X
Pacific white-sided dolphin	*Lagenorhynchus obliquidens*	X
Northern right whale dolphin	*Lissodelphis borealis*	X
Spinner dolphin	*Stenella coeruleoalba*	X
Pilot whale	*Globicephala macrorhynchus*	X
False killer whale	*Pseudorca crassidens*	
Killer whale	*Orcinus orca*	X
Risso's dolphin	*Grampus griseus*	X
Sperm whale	*Physeter macrocephalus*	X
Pygmy sperm whale	*Kogia breviceps*	
Dwarf sperm whale	*Kogia sinus*	
Baird's beaked whale	*Berardius bairdii*	

Table 1. Continued.

Species	Scientific name	Included
Cuvier's beaked whale	*Ziphius cavirostris*	
Stejneger's beaked whale	*Mesoplodon stejnegeri*	
Blainville's beaked whale	*Mesoplodon densirostris*	
Hubb's beaked whale	*Mesoplodon carlhubbsi*	
Ginkgo-toothed beaked whale	*Mesoplodon ginkgodens*	
Hector's beaked whale	*Mesoplodon hectori*	
Baleen whales	**Cetacea, suborder Mysteceti**	
Gray whale	*Eschrichtius robustus*	X
Northern right whale	*Eubalaena glacialis*	
Blue whale	*Balaenoptera musculus*	X
Fin whale	*Balaenoptera physalus*	X
Sei whale	*Balaenoptera borealis*	
Bryde's whale	*Balaenoptera edeni*	
Minke whale	*Balaenoptera acutorostrata*	X
Humpback whale	*Megaptera novaeangliae*	X

Table 2. Stranded (dead) marine mammals reported to NMFS, 1983–1991.

Species	County						All SCB	Other CA
	San Diego	Orange	Los Angeles	Ventura	Santa Barbara	Chan. Is.		
PINNIPEDS								
Northern sea lion	0	0	0	0	0		0	43
California sea lion	160	428	333	187	52	1	1161	819
Harbor seal	21	17	42	30	18		128	281
Elephant seal	8	7	12	15	12	2	56	112
Northern fur seal	0	0	1	2	0		3	26
Unidentified pinniped	108	36	188	182	24		538	40
MYSTECETES								
Blue whale	1	0	2	0	0	1	4	5
Fin whale	2	0	1	0	0	1	4	1
Bryde's whale	0	1	0	0	0		1	0
Minke whale	2	1	1	0	0	1	5	6
Humpback whale	1	0	0	0	0	1	2	2
Gray whale	13	13	11	7	10	3	57	56
ODONTOCETES								
Common dolphin	24	32	27	5	18	4	110	26
Bottlenose dolphin	18	18	5	4	1		46	2
Killer whale	0	1	0	0	0		1	2
Risso's dolphin	2	2	4	0	1	8	17	12
Pacific white-sided dolphin	4	6	3	3	6	1	23	21
Striped dolphin	2	0	0	0	0		2	3
Pilot whale	1	0	2	0	0	3	6	3
Spinner dolphin	0	0	1	0	0		1	0
Rough-toothed dolphin	0	0	0	0	0		0	2
Northern right whale dolphin	0	0	0	0	0	3	3	3
Harbor porpoise	0	0	0	0	3		3	236
Dall's porpoise	0	0	1	0	0		1	11
Sperm whale	0	1	0	0	0		1	9
Pigmy sperm whale	0	0	0	2	0		2	2
Ginkgo-toothed beaked whale	0	1	0	0	1		2	1
Blainville's beaked whale	0	0	0	1	0		1	1
Cuvier's beaked whale	0	0	0	0	0		0	7
Mesoplodon	0	0	0	0	0		0	1
Unidentified cetacean	2	13	2	3	3	2	25	12

Table 3. Stranded (dead) marine mammals in S Califoirnia reported to NMSS, 1982–1991. Includes Channel Is., San Diego, Orange, Los Angeles, Ventura, and Santa Barbara counties.

	Year											
Species	82*	83	84	85	86	87	88	89	90	91		Total
PINNIPEDS												
California sea lion	9	334	111	83	32	27	22	162	171	210		1161
Harbor seal	1	22	6	13	14	5	13	14	22	18		128
Elephant seal		14	6	3	1	3	2	7	3	17		56
Northern fur seal		1	0	0	0	0	0	0	1	1		3
Unidentified pinniped	1	24	7	2	2	0	0	115	284	103		538
MYSTECETES												
Blue whale		0	1	0	1	1	1	0	0	0		4
Fin whale		1	0	0	1	0	1	0	0	1		4
Bryde's whale	1	0	0	0	0	0	0	0	0	0		1
Minke whale		1	0	0	0	0	1	2	1	0		5
Humpback whale		1	0	0	0	0	0	0	0	1		2
Gray whale	1	5	6	12	4	11	2	8	5	3		57
ODONTOCETES												
Common dolphin	1	8	6	14	10	11	17	18	15	10		110
Bottlenose dolphin	1	9	2	6	3	4	5	4	7	5	**	46
Killer whale		0	0	1	0	0	0	0	0	0		1
Risso's dolphin		0	0	0	0	0	10	3	1	3		17
Pacific white-sided dolphin		5	6	3	1	2	2	1	2	1		23
Striped dolphin		2	0	0	0	0	0	0	0	0		2
Northern right-whale dolphin		0	0	0	0	0	1	1	1	0		3
Pilot whale		3	0	0	0	1	1	0	1	0		6
Spinner dolphin		1	0	0	0	0	0	0	0	0		1
Harbor porpoise		1	0	2	0	0	0	0	0	0		3
Dall's porpoise		0	0	0	0	0	0	1	0	0		1
Sperm whale		1	0	0	0	0	0	0	0	0		1
Pigmy sperm whale		1	1	0	0	0	0	0	0	0		2
Ginkgo-toothed beaked whale		0	1	0	1	0	0	0	0	0		2
Blainville's beaked whale		0	1	0	0	0	0	0	0	0		1
Unidentified cetacean		6	2	0	4	1	1	0	4	7		25
TOTAL	15	440	156	139	74	66	79	336	518	380		2203

* Incomplete for 1992 and includes 2 strandings with incoplete date information

** Includes one stranding from 1992

Table 4. Concentrations of PCBs and DDTs (ppm, wet weight) in common dolphins from southern California.

					Blubber			Liver			Muscle			Brain			
Yr	Sex	Len	Age	Location	DDE	TDDT	PCB	DDE	TDDT	PCB	DDE	TDDT	PCB	DDE	TDDT	PCB	Source
75	F	182		Corona del Mar, OC	730	820	80				5.5	6.0	0.60				O'Shea et al. 1980
74	F	192		Malibu Bch., LAC	360	450	100				4.3	4.8	0.70	14	15	2.20	O'Shea et al. 1980
75	F	210		Zuma Bch., LAC	950	1100	160				13	21	3.3				O'Shea et al. 1980
74	F	179		Newport Bch, OC										20	21	0.65	O'Shea et al. 1980
75	M	184		Leucadia S.B., SDC	980	1100	110				16	17	2.3	20	21	0.70	O'Shea et al. 1980
75	M	184		Santa Monica, LAC	780	910	160				11	12	0.43				O'Shea et al. 1980
75	M	187		Leucadia S.B., SDC	510	600	110				5.3	5.5		10	11		O'Shea et al. 1980
74	M	190		Hermosa Bch, LAC	1500	1800	80				38	41	2.4	45	48	2.7	O'Shea et al. 1980
74	M	192		Will Rogers Bch, LA	740	860	160				10	11	1.2	17	18	2.0	O'Shea et al. 1980
76	M	195		Carlsbad Bch, SDC	780	860	88				7.5	8.2	0.78	14	15	2.4	O'Shea et al. 1980
74	M	196		Seal Bch, OC	560	650	110				8.3	8.6	0.78	11	12	1.2	O'Shea et al. 1980
74	M	198		Will Rogers Bch, LA	500	570	92				16	17	0.70				O'Shea et al. 1980
74	M	201		Santa Monica, LAC	1200	1400	300				14	15	1.2	22	23	1.8	O'Shea et al. 1980
75	M	204		Corona del Mar, OC	1700	1800	140				14	15	1.7	41	44	4.2	O'Shea et al. 1980
71	-		A	Los Angeles Co.				64.0	69.0	3.8							Britt and Howard 1983
74	-		A	Los Angeles Co.				62.0	67.0	4.7							Britt and Howard 1983
74	-		A	Los Angeles Co.				0.84	1.1	0.0							Britt and Howard 1983
74	-		A	Los Angeles Co.				91.0	98.2	11.0							Britt and Howard 1983
76	-		A	Los Angeles Co.				20.0	21.8	19.0							Britt and Howard 1983
77	-		A	Los Angeles Co.				2.9	2.9	0.5							Britt and Howard 1983
78	M	185	A	southern Calif.		451	25.6		34.9	9.47		4.33	3.08		6.90		Schafer et al. 1984
79	F	176	A	southern Calif.		330	11.3		33.6	1.54		0.28	0.13			1.19	Schafer et al. 1984
79	M	231	A	southern Calif.		344	2.47		8.6	0.35		1.44	0.09		7.18	0.52	Schafer et al. 1984
80	M	175	A	southern Calif.		591	12.9		107	1.25		39.30	0.69				Schafer et al. 1984
80	M	190	A	southern Calif.		610	15.0		22.4	0.73		2.79	0.04				Schafer et al. 1984
83	M	185	A	southern Calif.		156	5.01		4.4	0.38		2.09	0.23		2.25		Schafer et al. 1984
83	M	-	A	southern Calif.		1.2	0.08		1.9	0.08		1.11	0.08				Schafer et al. 1984
83	M	202	A	southern Calif.		392	5.24		20.8	0.36		1.12	0.02		2.50	0.03	Schafer et al. 1984
83	-	-	-	southern Calif.		45.5	5.73		2.5	0.06		0.38	0.04		0.62	0.04	Schafer et al. 1984
84	M	193	A	southern Calif.		40.8	8.68		0.8	0.04		0.52	0.01		0.58	0.04	Schafer et al. 1984
84	M	203	A	southern Calif.		83.0	7.81		1.0	0.09		1.03	0.06				Schafer et al. 1984
71	-			Belmont Shores	191	212	235	5.3	5.8	3.9				2.5	2.7	1.9	Gerlinger 1971
84	M	197		southern Calif.		3	0.5		1.4	0.40							Kelly 1990a

Table 5. Concentrations of PCBs and DDTs (ppm, wet weight) in small cetaceans from southern California.

					Blubber			Liver			Muscle			Brain			
Yr	Sex	Len	Age	Location	DDE	TDDT	PCB	DDE	TDDT	PCB	DDE	TDDT	PCB	DDE	TDDT	PCB	Source
Bottlenose dolphin																	
80	M	121	.1yr	southern Calif.		230	9.70		16.5	0.83							Schafer et al. 1984
82	M	206		southern Calif.		573	73.2						0.35				Schafer et al. 1984
83	M	266		southern Calif.		1922	128					20.8	0.84				Schafer et al. 1984
86	M	312		Orange Co		910	265										Kelly 1990b
80	F	127	.1yr	southern Calif.		126	9.78		5.38	0.05		1.30	0.19				Schafer et al. 1984
85	F	128		Orange Co		150	3.10		144	15							Kelly 1990b
80	F	168	1	southern Calif.					6.92	0.50							Schafer et al. 1984
84	F	203	<3	southern Calif.		2070	44.5		196	8.16					17.9	0.46	Schafer et al. 1984
76	F	211	Imm	San Diego Co.	1600	1800	420				49	55	15				O'Shea et al. 1980
76	F	255	Imm	San Diego Co.	2500	2700	450				18	19	5.5				O'Shea et al. 1980
83	F	287	28	southern Calif.		653						20.1					Schafer et al. 1984
71	F			Catalina Is	165	195	115	10.1	11.3	1.4				5.6	6.2		Gerlinger 1971
Northern right whale dolphin																	
71	F			Santa Monica Pier	113	164.2	49	4.9	8.6					2	2.99		Gerlinger 1971
Pacific white-sided dolphin																	
77	-			southern Calif.		2.08	0.23		1.63	0.26		2.6	0.18				Schafer et al. 1984
82	-			southern Calif.		99.5	4.88					3.96	0.22				Schafer et al. 1984
Harbor porpoise																	
-	F	140		Moro Bay, S. Ca.	270	334.8	84				2	2.2	0.5	2.2	2.35	0.65	O'Shea et al. 1980
83	F	138		Moro Bay, S. Ca.	85		16										Calambokidis and Barlow
83	M	134		Moro Bay, S. Ca.	132		22										Calambokidis and Barlow
Dall's porpoise																	
71	-			Venice	195	213	108	10	11.64	18.3				2.4	2.6	4.9	Gerlinger 1971
-	F	183		southern Calif.	190	245.8	94				3.8	3.97	0.53				O'Shea et al. 1980

Table 6. Concentrations of PCBs and DDTs (ppm, wet weight) in toothed whales from southern and central California.

					Blubber			Liver			Muscle			Brain			
Yr	Sex	Len	Age	Location	DDE	TDDT	PCB	DDE	TDDT	PCB	DDE	TDDT	PCB	DDE	TDDT	PCB	Source
Pilot whale																	
-	F	457		southern Calif.	30	35.08	8.8				0.53	0.53					O'Shea et al. 1980
-	M	670		southern Calif.	110	130.1	14				6.5	7.46	0.88				O'Shea et al. 1980
71				San Clemente Is.				1.06	(Mean of 5 animals, range 0.29-2.4)								Hall et al. 1971
Sperm whale																	
83	M		.1 y	southern Calif.		5.08	0.51					0.05	0.01				Schafer et al. 1984
68	M	12.2	mat	off San Francisco	6.0	9.4		0.33	0.44					0.12	0.16		Wolman and Wilson 197
68	M	14.9	mat	off San Francisco	0.74	1.82		0.15	0.29					0.014	0.014		Wolman and Wilson 197
68	F	10.3	mat	off San Francisco	4.0	5.7		0.35	0.49					0.059	0.059		Wolman and Wilson 197
68	F	10.8	mat	off San Francisco	3.3	5.1		0.23	0.28					0.054	0.067		Wolman and Wilson 197
68	F	11.2	mat	off San Francisco	4.4	7.1		0.19	0.26					0.073	0.099		Wolman and Wilson 197
68	F	10.9	mat	off San Francisco	3.3	5.7		0.18	0.27					0.074	0.096		Wolman and Wilson 197

Table 7. Concentrations of PCBs and DDTs (ppm, wet weight) in baleen whales from southern and central California.

					Blubber			Liver			Muscle			Brain			
Yr	Sex	Len	Age	Location	DDE	TDDT	PCB	DDE	TDDT	PCB	DDE	TDDT	PCB	DDE	TDDT	PCB	Source
Gray whale																	
76	-		1 y	southern Calif.		0.47	0.23		8.4	0.43		0.04	0.03		0.53	0.09	Schafer et al. 1984
68	M	10.7	im	off San Francisco	0.040	0.100								0	0		Wolman and Wilson 1970
68	M	11.8	mat	off San Francisco	0.041	0.097								0	0		Wolman and Wilson 1970
68	M	10.9	im	off San Francisco	0.046	0.108								0	0		Wolman and Wilson 1970
68	F	9.4	im	off San Francisco	0.046	0.132								0	0		Wolman and Wilson 1970
68	F	12.9	mat	off San Francisco	0	0								0	0		Wolman and Wilson 1970
68	M	11.3	mat	off San Francisco	0	0								0	0		Wolman and Wilson 1970
68	F	13.2	mat	off San Francisco	0	0								0	0		Wolman and Wilson 1970
68	M	11.9	mat	off San Francisco	0	0								0	0		Wolman and Wilson 1970
69	M	12.2	mat	off San Francisco	0	0								0	0		Wolman and Wilson 1970
69	F	13.3	mat	off San Francisco	0.30	0.52								0.011	0.011		Wolman and Wilson 1970
69	F	11.6	mat	off San Francisco	0	0								0	0		Wolman and Wilson 1970
69	F	13.4	mat	off San Francisco	0	0								0	0		Wolman and Wilson 1970
69	F	12.2	mat	off San Francisco	0	0											Wolman and Wilson 1970
69	F	11.3	im	off San Francisco	0	0								0	0		Wolman and Wilson 1970
69	M	11.3	im	off San Francisco	0	0								0	0		Wolman and Wilson 1970
69	M	10.9	mat	off San Francisco	0	0								0	0		Wolman and Wilson 1970
69	M	12.4	mat	off San Francisco	0	0								0	0		Wolman and Wilson 1970
69	M	11.9	mat	off San Francisco	0	0								0	0		Wolman and Wilson 1970
69	M	12.4	mat	off San Francisco	0	0								0	0		Wolman and Wilson 1970
69	M	11.8	mat	off San Francisco	0.36	0.68								0.011	0.011		Wolman and Wilson 1970
69	F	12.7	mat	off San Francisco	0	0								0	0		Wolman and Wilson 1970
69	F	11.9	im	off San Francisco	0	0								0	0		Wolman and Wilson 1970
69	F	12.9	im	off San Francisco	0	0								0	0		Wolman and Wilson 1970
Minke whale																	
77	F		Ad.	southern Calif.		587	27.8		11.6	0.74		5.44	0.3		43	5.32	Schafer et al. 1984

No detection limit given for 0 values reported for gray whales by Wolman and Wilson (1970).

Table 8. Concentrations of PCBs and DDTs (ppm, wet weight) in California sea lions.
Values for pooled samples and regions outside the SCB listed at end of table.

					Blubber				Liver				Brain				
Yr	Sex	Status	Age	Location	n	DDE	DDT	PCB	n	DDE	DDT	PCB	n	DDE	DDT	PCB	Source
73	M		1-2	LA County					1	111	125.8	15					Britt and Howard 1983
76	M		1-2	LA County					1	21	27.9	0					Britt and Howard 1983
77	M		1-2	LA County					1	439	500	67					Britt and Howard 1983
77	M		1-2	LA County					1	0.27	1.25	87					Britt and Howard 1983
79	M		1-2	LA County					1	123	155	25					Britt and Howard 1983
80	M		1-2	LA County					1	118	148.5	28					Britt and Howard 1983
80	M		1-2	LA County					1	36	44.7	19					Britt and Howard 1983
80	M		1-2	LA County					1	9	11.5	11					Britt and Howard 1983
80	M		1-2	LA County					1	0.48	0.48	0.67					Britt and Howard 1983
80	M		1-2	LA County					1	3	3.075	1.1					Britt and Howard 1983
80	M		1-2	LA County					1	22	22.81	3.5					Britt and Howard 1983
80	M		1-2	LA County					1	8.1	10.05	0					Britt and Howard 1983
80	M		1-2	LA County					1	22	22.27	3.3					Britt and Howard 1983
80	M		1-2	LA County					1	5.1	5.1	0.47					Britt and Howard 1983
80	M		1-2	LA County					1	1	1.28	2					Britt and Howard 1983
80	M		1-2	LA County					1	117	130.4	16					Britt and Howard 1983
80	M		1-2	LA County					1	5.6	6.57	5					Britt and Howard 1983
81	M		1-2	LA County					1	1.6	2.09	3.4					Britt and Howard 1983
70	F		1-2	LA County					1	366	434	90					Britt and Howard 1983
74	F		1-2	LA County					1	3.8	4.01	0.95					Britt and Howard 1983
75	F		1-2	LA County					1	47	57.2	0					Britt and Howard 1983
76	F		1-2	LA County					1	7.6	7.6	1.1					Britt and Howard 1983
77	F		1-2	LA County					1	32	39.1	25					Britt and Howard 1983
78	F		1-2	LA County					1	1.8	2.03	0					Britt and Howard 1983
79	F		1-2	LA County					1	54	63	15					Britt and Howard 1983
79	F		1-2	LA County					1	11	11.83	3.8					Britt and Howard 1983
79	F		1-2	LA County					1	160	176	11					Britt and Howard 1983
79	F		1-2	LA County					1	9.8	9.8	8.9					Britt and Howard 1983
79	F		1-2	LA County					1	10	10.94	6.5					Britt and Howard 1983

Table 8. Continued

Yr	Sex	Status	Age	Location	Blubber n	Blubber DDE	Blubber DDT	Blubber PCB	Liver n	Liver DDE	Liver DDT	Liver PCB	Brain n	Brain DDE	Brain DDT	Brain PCB	Source
79	F		1-2	LA County					1	24	24	8.4					Britt and Howard 1983
80	F		1-2	LA County					1	15	15.6	8.3					Britt and Howard 1983
80	F		1-2	LA County					1	48	58.1	8.9					Britt and Howard 1983
80	F		1-2	LA County					1	4	4.6	1.6					Britt and Howard 1983
80	F		1-2	LA County					1	3	3.31	1.7					Britt and Howard 1983
80	F		1-2	LA County					1	35	39.8	6.2					Britt and Howard 1983
80	F		1-2	LA County					1	3.9	4.08	2					Britt and Howard 1983
80	F		1-2	LA County					1	1.3	1.3	1.8					Britt and Howard 1983
80	F		1-2	LA County					1	64	77.6	30					Britt and Howard 1983
80	F		1-2	LA County					1	22	22.14	5.2					Britt and Howard 1983
70	M		A	LA County					1	36.0	43.2	2.2					Britt and Howard 1983
77	M		A	LA County					1	164.0	168.4	55.0					Britt and Howard 1983
79	M		A	LA County					1	6.4	7.18						Britt and Howard 1983
79	M		A	LA County					1	1.6	2.01	0.8					Britt and Howard 1983
79	M		A	LA County					1	200.0	208.1	15.0					Britt and Howard 1983
79	M		A	LA County					1	181.0	245.0	59.0					Britt and Howard 1983
80	M		A	LA County					1	118.0	148.5	28.0					Britt and Howard 1983
80	M		A	LA County					1	4.7	5.13	3.3					Britt and Howard 1983
80	M		A	LA County					1	34.0	35.11	6.9					Britt and Howard 1983
80	M		A	LA County					1			3.3					Britt and Howard 1983
73	F		A	LA County					1	67.0	69.0	9.4					Britt and Howard 1983
75	F		A	LA County					1	0	0.56						Britt and Howard 1983
75	F		A	LA County					1	0	0						Britt and Howard 1983
75	F		A	LA County					1	0	0.17						Britt and Howard 1983
77	F		A	LA County					1	1.0	1.65						Britt and Howard 1983
79	F		A	LA County					1	0.51	0.51	0.7					Britt and Howard 1983
79	F		A	LA County					1	35.0	35.9						Britt and Howard 1983
79	F		A	LA County					1	139.5	153.5	25.0					Britt and Howard 1983
79	F		A	LA County					1	11.0	11.0	15.0					Britt and Howard 1983

Table 8. Continued

Yr	Sex	Status	Age	Location	Blubber n	Blubber DDE	Blubber DDT	Blubber PCB	Liver n	Liver DDE	Liver DDT	Liver PCB	Brain n	Brain DDE	Brain DDT	Brain PCB	Source
79	F		A	LA County					1	21.0	29.2	19.0					Britt and Howard 1983
79	F		A	LA County					1	103.0	111.8	23.0					Britt and Howard 1983
80	F		A	LA County					1	10.0	11.8	1.7					Britt and Howard 1983
80	F		A	LA County					1	78.0	78.84	25.0					Britt and Howard 1983
80	F		A	LA County					1	10.0	10.0	4.8					Britt and Howard 1983
81	F		A	LA County					1	0.25	0.95	1.47					Britt and Howard 1983
81	F		A	LA County					1	0	0	3.46					Britt and Howard 1983
72	F	Prem	7	San Miguel Is	1	580	598	49.4	1	26.6	29.8	4.34					Gilmartin et al 1976
72	F	Prem	6	San Miguel Is	1	879	900	67.4	1	13.7	14.0	3.10					Gilmartin et al 1976
72	F	Prem	7	San Miguel Is	1	355	371	33.0	1	8.54	8.57	0.63					Gilmartin et al 1976
72	F	Prem	6	San Miguel Is	1	927	957	57.5	1	24.1	24.3	1.22					Gilmartin et al 1976
72	F	Prem	7	San Miguel Is	1	350	365	47.1	1	13.0	13.1	0.77					Gilmartin et al 1976
72	F	Prem	8	San Miguel Is	1	633	648	54.1	1	19.6	19.7	2.53					Gilmartin et al 1976
72	F	Prem	3-14	San Miguel Is	1	375	400	56.4	1	12.4	12.7	4.13					Gilmartin et al 1976
72	F	Prem	8	San Miguel Is					1	20.7	20.9	4.35					Gilmartin et al 1976
72	F	Prem	7	San Miguel Is	1	939	974	92.4	1	30.4	31.3	6.08					Gilmartin et al 1976
72	F	Term	13	San Miguel Is	1	82.6	88.7	12.1	1	5.98	6.39	1.86					Gilmartin et al 1976
72	F	Term	10	San Miguel Is	1	24.1	26.4	5.19	1	1.42	1.48	0.43					Gilmartin et al 1976
72	F	Term	10	San Miguel Is	1	141	147	20.8	1	4.72	4.78	1.07					Gilmartin et al 1976
72	F	Term	11	San Miguel Is	1	342	351	39.5	1	18.2	18.4	1.98					Gilmartin et al 1976
72	F	Term	3-14	San Miguel Is	1	24.3	27.5	8.31	1	0.93	0.97	0.28					Gilmartin et al 1976
72	F	Term	13	San Miguel Is	1	16.3	18.5	5.39	1	1.08	1.14	0.19					Gilmartin et al 1976
72	F	Term	10	San Miguel Is	1	17.4	19.9	4.73	1	1.15	1.18	0.24					Gilmartin et al 1976
72	F	Term	11	San Miguel Is	1	31.5	36.4	6.33	1	1.38	1.42	0.41					Gilmartin et al 1976
72	F	Term	12	San Miguel Is	1	23.3	27.2	5.16	1	1.17	1.23	0.43					Gilmartin et al 1976
72	F	Term	12	San Miguel Is	1	127	133	24.1	1	5.54	5.63	1.04					Gilmartin et al 1976
70	F	Prem	6-12	San Miguel Is	6		824	112	3		25.2	5.74					DeLong et al. 1972
70	F	Term	0-15	San Miguel Is	4		103	17	4		6.67	1.32					DeLong et al. 1972
70	M&F	Prem	Pup	San Miguel Is									6		2.38	0.45	DeLong et al. 1972

Table 8. Continued

					Blubber				Liver				Brain				
Yr	Sex	Status	Age	Location	n	DDE	DDT	PCB	n	DDE	DDT	PCB	n	DDE	DDT	PCB	Source
70	M&F	Term	Pup	San Miguel Is									4		1.2	0.19	DeLong et al. 1972
70	M&F	Healthy	A	San Miguel and Ano Nuevo	5		906		7		17		4		8.6		Le Boeuf and Bonnell 197
70	M	Sick		Montery to San Francisco	6		689						5		13		Le Boeuf and Bonnell 197
70	M	Stranded		Ano Nuevo	14		1006						6		14		Le Boeuf and Bonnell 197
71	M	Healthy	4-8	cent. Oregon	6	253		34.1	6	11.1		4.87	5	9.16		2.82	
73	M	Healthy	4-6	cent. Oregon	3	342		21.2	3	12.9		2.39	3	3.02		0.49	
70	M	Sick	5-9	cent. Oregon	7	358		24.2	8	23.9		2.79	5	8.27		1.6	
71	M	Sick	4-5	cent. Oregon	2	475		28.5	2	11.2		1.95					

Table 9. Concentrations of PCBs and DDTs (ppm, wet weight) in harbor seals from California.

					Blubber			Liver			Muscle			Brain			
Yr	Sex	Len	Age	Location	DDE	TDDT	PCB	DDE	TDDT	PCB	DDE	TDDT	PCB	DDE	TDDT	PCB	Source
76	M		SA	LA County				8.7	8.7	14							Britt and Howard 1983
79	M		SA	LA County				11	11	0.18							Britt and Howard 1983
79	M		SA	LA County				92	101	11							Britt and Howard 1983
80	F		SA	LA County				26	28.3	7.1							Britt and Howard 1983
75	M		PR	Humboldt Co.				0.10	0.10	0.071	0.24	0.32	0.12	0.049	0.22	0.036	Risebrough 1978
75	F		PR	Ano Nuevo Bch	16	16	9.2	0.29	0.32	0.19	1.8	1.9	1.3	0.15	0.17	0.13	Risebrough 1978
75	M		P	south S.F. Bay							0.22	0.29	0.51				Risebrough 1978
76	M		P	south S.F. Bay				0.046	0.054	0.33	0.081	0.093	0.31				Risebrough 1978
76	M		P	Pt. Reyes	10	10	3.5				0.68	0.68	0.21				Risebrough 1978
76	M		P	S.F. Bay, Mowry	13	15	89	0.21	0.25	1.0	0.25	0.30	1.7	0.096	0.27	0.074	Risebrough 1978
76	F		P	S.F. Bay, Mowry	13	13	41				0.065	0.065	0.14	0.16	0.016	0.91	Risebrough 1978
76	M		P	S.F. Bay, Mowry	4.6	4.8	11	0.19	0.21	0.83	0.88	0.95	2.3	0.079	0.12	0.24	Risebrough 1978
76	-		P	S.F. Bay, Mowry	5.6	5.6	45	0.11	0.11	0.73	0.56	0.59	3.2	0.10	0.10	0.35	Risebrough 1978
76	M		P	Bodega Bay							3.0	3.0	3.4	5.0	5.0	3.9	Risebrough 1978
75	-		P	Humboldt Co.				3.5	3.6	0.30							Risebrough 1978
75	F		1 y	Marin Co.	27	27	110	0.96	1.2	4.9	4.4	4.4	2.7	0.35	0.35	1.7	Risebrough 1978
75	F		1 y	Pt. Reyes	24	24	25	0.30	0.36	0.75	0.18	0.19	0.48				Risebrough 1978
75	M		A	Richardson Bay	130	130	410	44	51	410	18	22	93				Risebrough 1978
76	F		A	S.F. Bay, Mowry	57	59	130	1.4	1.5	4.0	3.4	3.6	11	0.79	0.93	1.7	Risebrough 1978
77	F		A	S.F. Bay, Richardson	37	42	230										Risebrough 1978
75	F		A	Pt Arena				1.0	1.1	0.35	0.14	0.14	0.068				Risebrough 1978
70	M			Cypress Pt	15	18		2.0	2.4		0.49	0.58		0.053	0.067		Shaw 1971
70	F			Pt. Joe	142	158		2.7	3.0					1.4	1.6		Shaw 1971
71	M	176	A	San Miguel Is.	2110	2210	572										Anas 1974

Table 10. Concentrations of PCBs and DDTs (ppm, wet weight) in fur and elephant seals and sea otters from California.

					Blubber			Liver			Muscle			Brain			
Yr	Sex	Len	Age	Location	DDE	TDDT	PCB	DDE	TDDT	PCB	DDE	TDDT	PCB	DDE	TDDT	PCB	Source
Northern fur seal																	
79	F		SA	LA County				12.5	15.2	9.7							Britt and Howard 1983
80	M		SA	LA County				12.9	15.13	5.9							Britt and Howard 1983
80	F		SA	LA County				11.1	11.1	1.9							Britt and Howard 1983
80	F		SA	LA County				3.9	4.81	3.7							Britt and Howard 1983
Elephant seal																	
74	M		P	LA County				0.16	0.28	0							Britt and Howard 1983
79	-		SA	LA County				12	13.2	2.5							Britt and Howard 1983
79	M		SA	LA County				9.6	9.6	3.2							Britt and Howard 1983
79	M		SA	LA County				15	15.0	9							Britt and Howard 1983
80	M		SA	LA County				44	44.77	2.6							Britt and Howard 1983
80	F		SA	LA County				3.4	3.4	0.56							Britt and Howard 1983
81	F		SA	LA County				51	51.16	2.5							Britt and Howard 1983
83	F	260	6 y	San Nic. Is., S. Ca.		2.76	0.26		0.24	0.01		0.09	0.01				Schafer et al. 1984
83	M	363	6 y	San Nic. Is., S. Ca.		9.74	0.31		0.96	0.44		0.59	0.03				Schafer et al. 1984
84	F	282	6 y	San Nic. Is., S. Ca.		7.07	0.74		0.06	0.004		0.16	0.01				Schafer et al. 1984
84	M	386	6 y	San Nic. Is., S. Ca.		11	4.04		0.29	0.03		0.05	0.01				Schafer et al. 1984
92	M&F	Health	juv.	Ano Nuevo, early molt n=8		2.8	0.62										Newman pers. comm. 19
92	M&F	Health	juv.	Ano Nuevo, late molt n=5		4.2	0.8										
92	M&F	Sick	juv.	Ano Nuevo, late molt n=6		3.9	1.5										
Sea otter																	
69	F			Morro Bay				0.49	0.52					0.17	0.18		Shaw 1971
70	M			Monterey Bay				14	15					9.2	10		Shaw 1971
70	M			Monterey Bay	7.7	8.1		0.87	0.94					0.53	0.80		Shaw 1971
70	F			Pt Lobos	1.1	1.2		0.55	0.65								Shaw 1971
70	F			Lover's Pt				7.8	7.9								Shaw 1971
70	M			Morro Bay	0.39	0.41		3.4	3.48					0.02	0.10		Shaw 1971
70	M			Cambria	34	36		0.11	0.13								Shaw 1971
70	M			Cambria	7.0	7.5		0.03	0.03								Shaw 1971
70	F			Hopkins Mar. Sta.	18	20		0.059	0.071								Shaw 1971
70	M			Monterey Bay	3.7	4.4		0.32	0.36								Shaw 1971

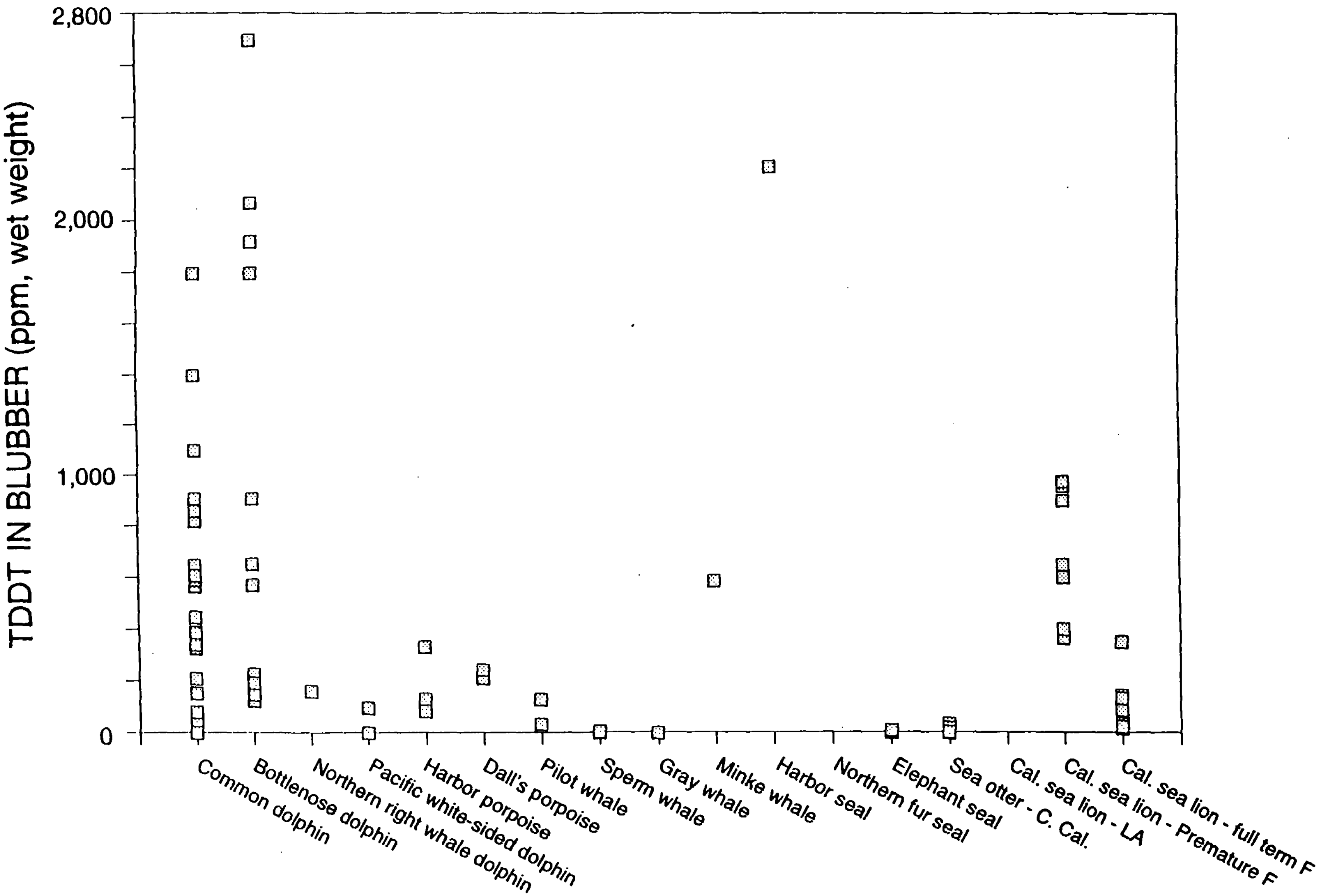


Figure 1. Total DDT in blubber of southern California marine mammals.

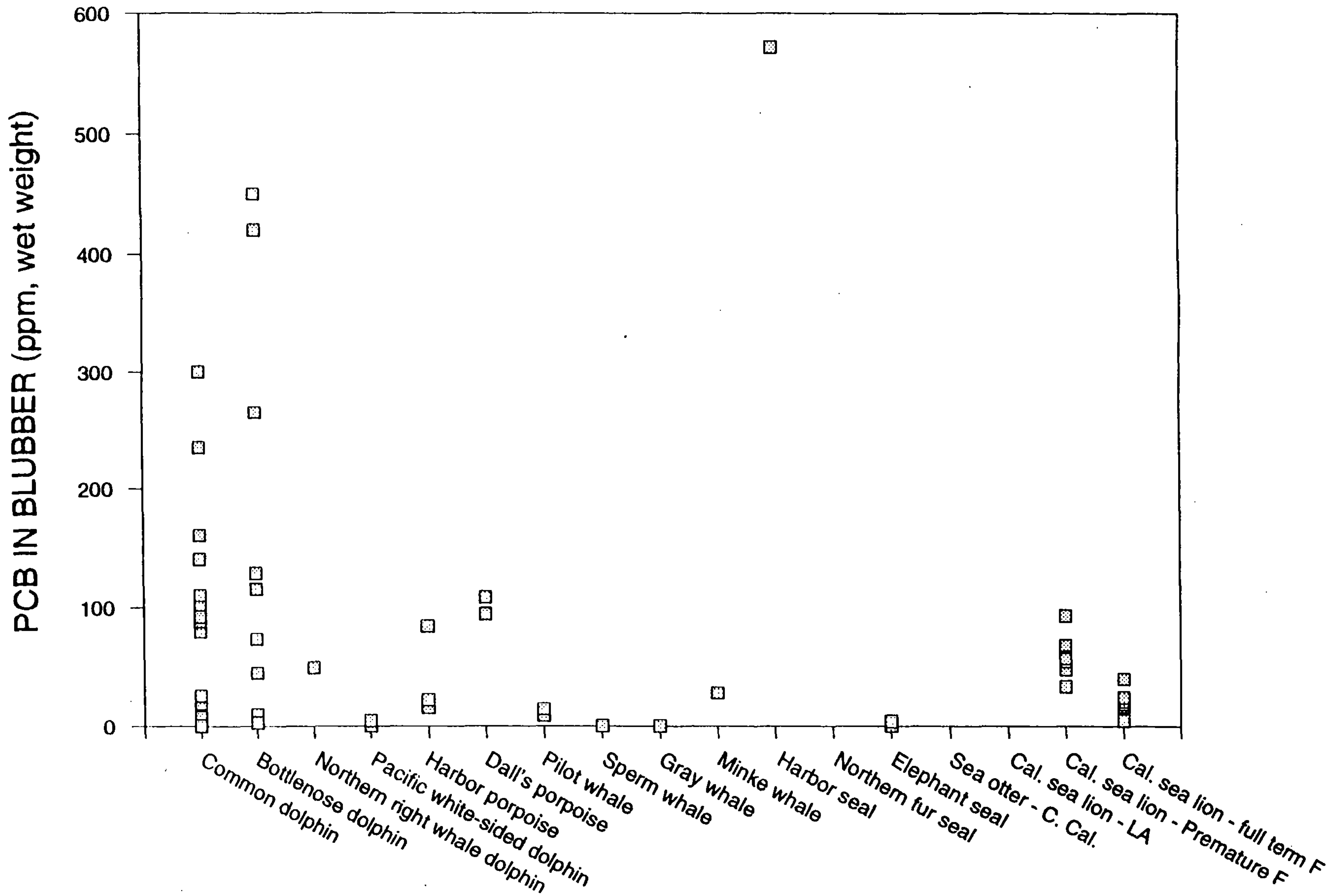


Figure 2. PCBs in blubber of southern California marine mammals.

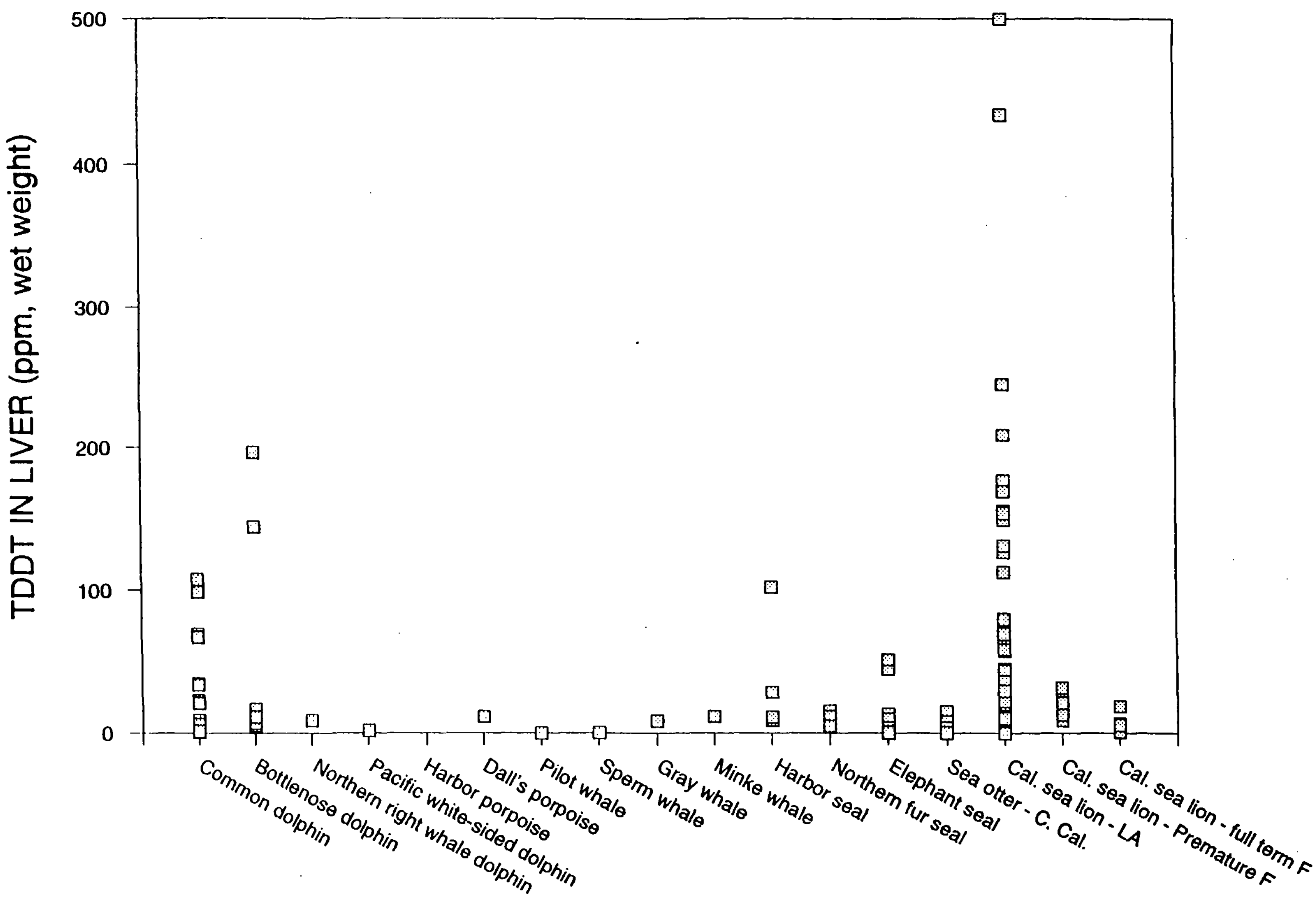


Figure 3. Total DDT in liver of southern California marine mammals.

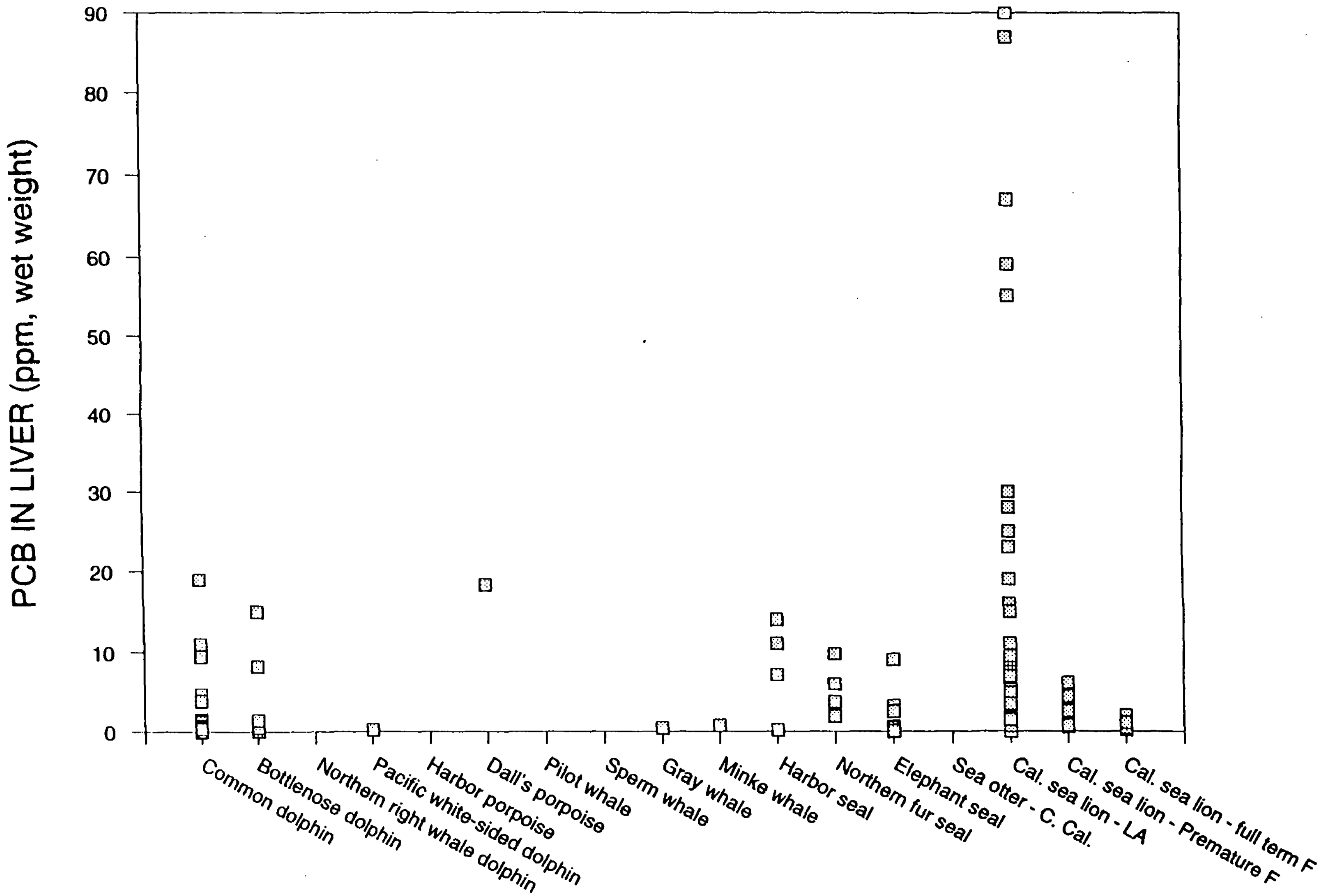


Figure 4. PCBs in liver of southern California marine mammals.

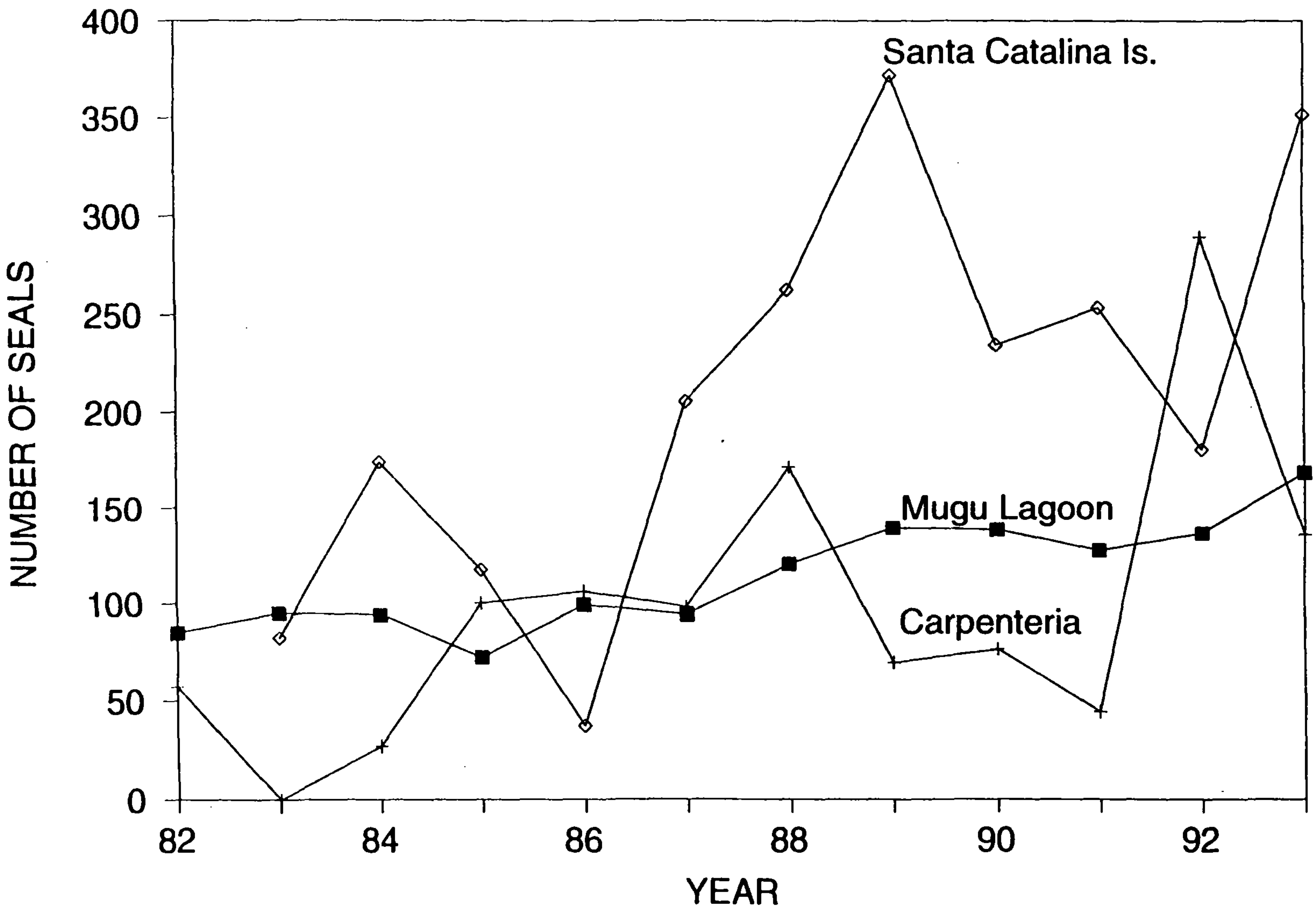
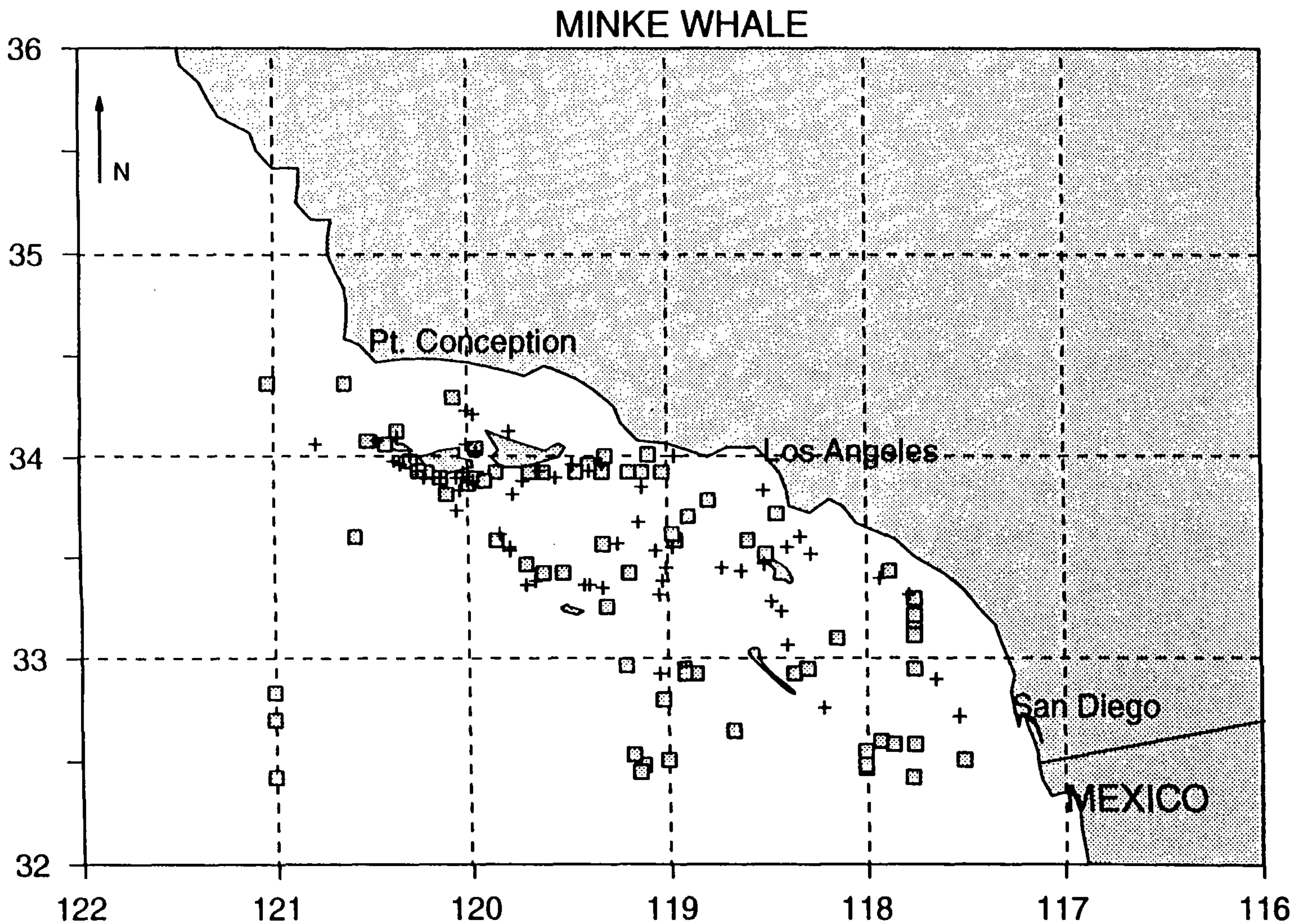


Figure 5. Trends in harbor seals at three sites in the SCB.
Data from Hanan et al. (1994).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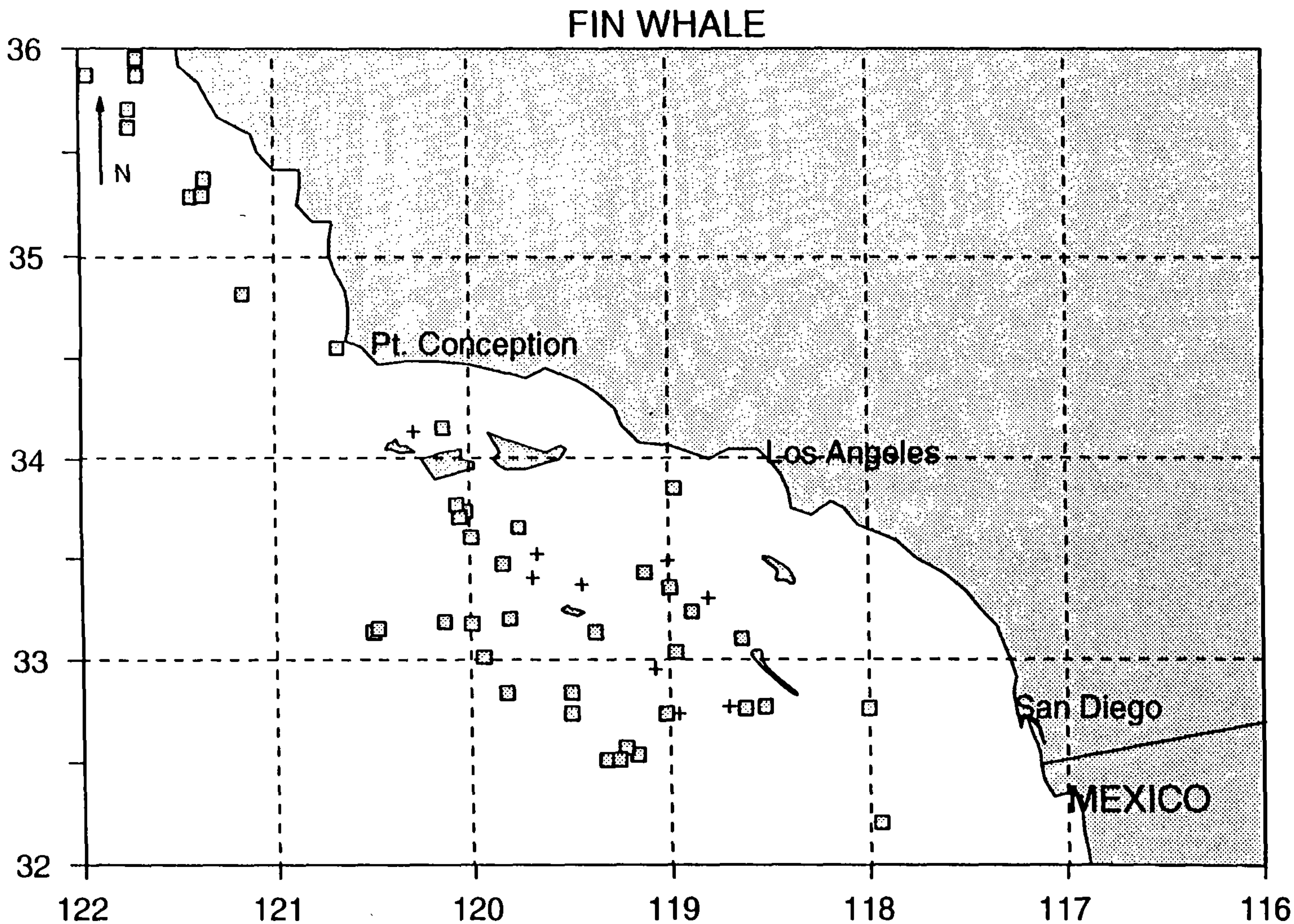
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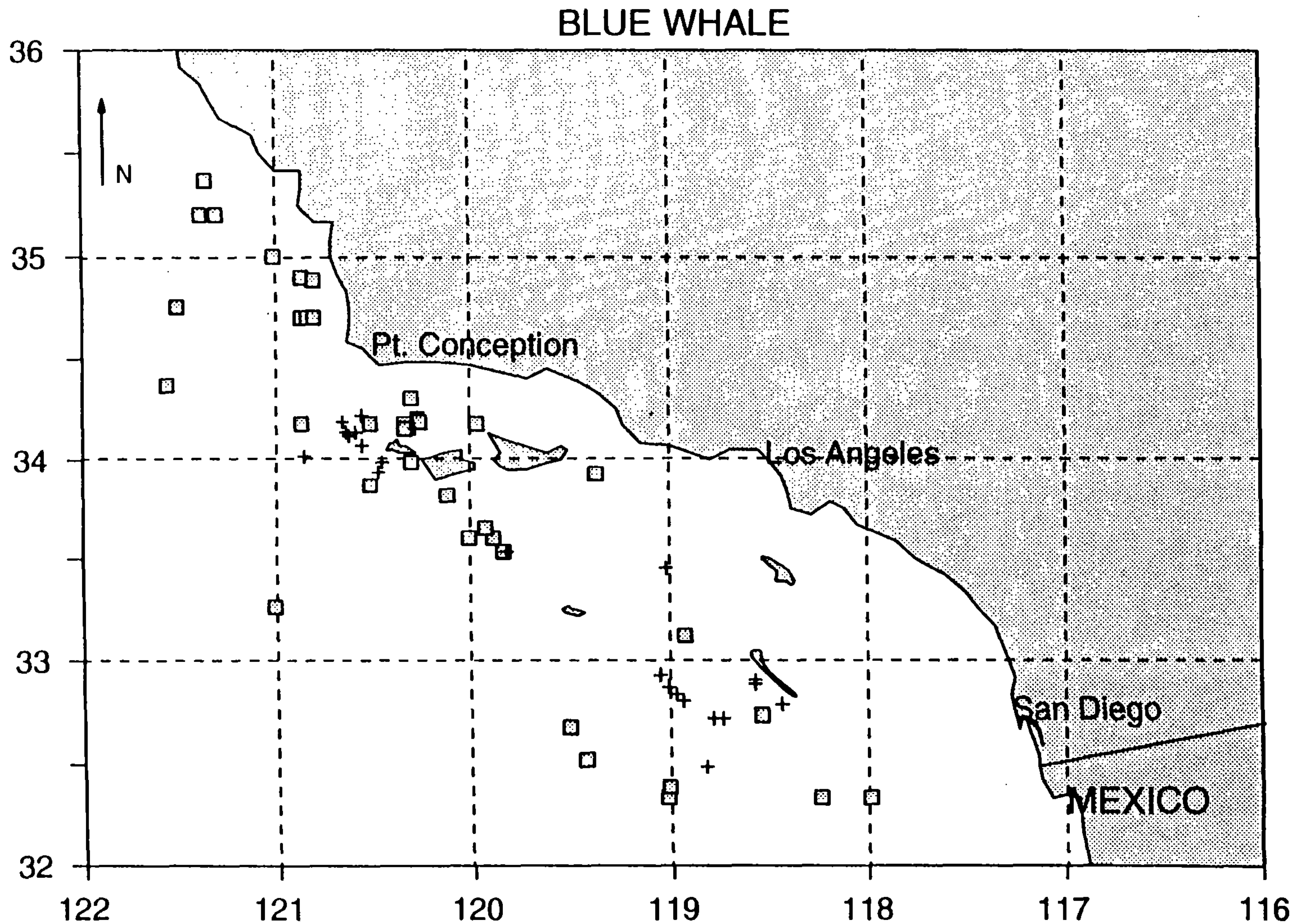
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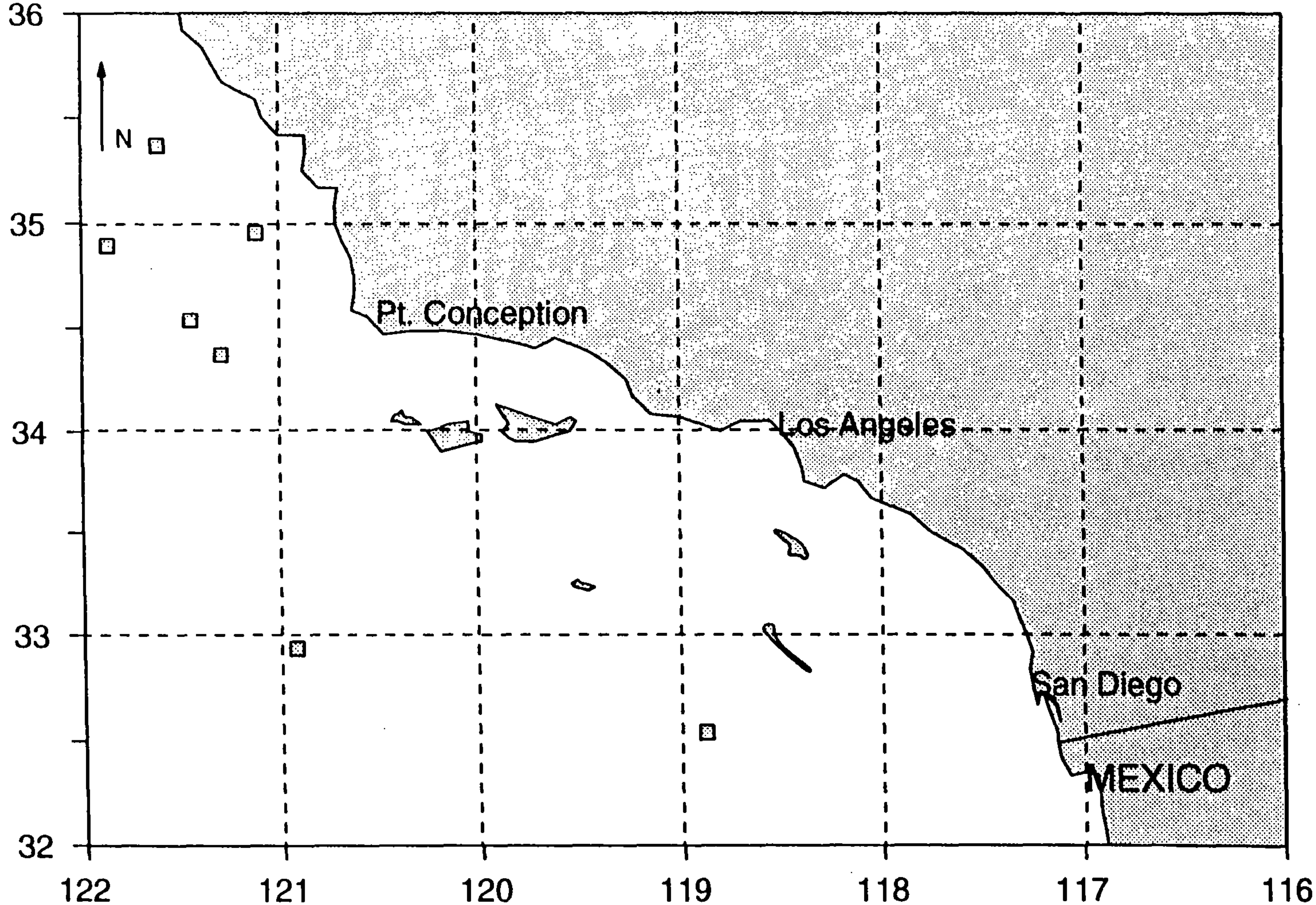
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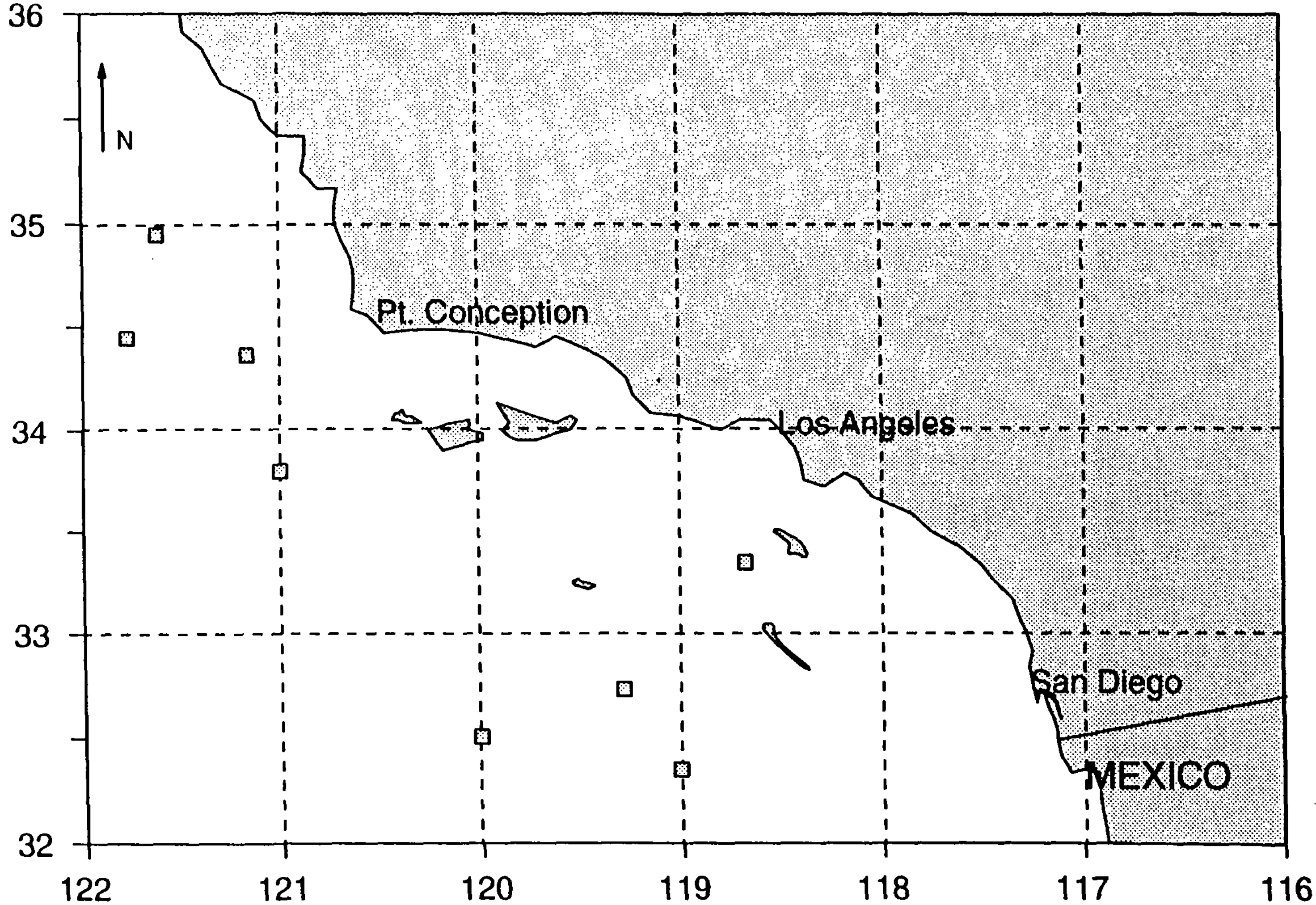
MESOPLODON BEAKED WHALE



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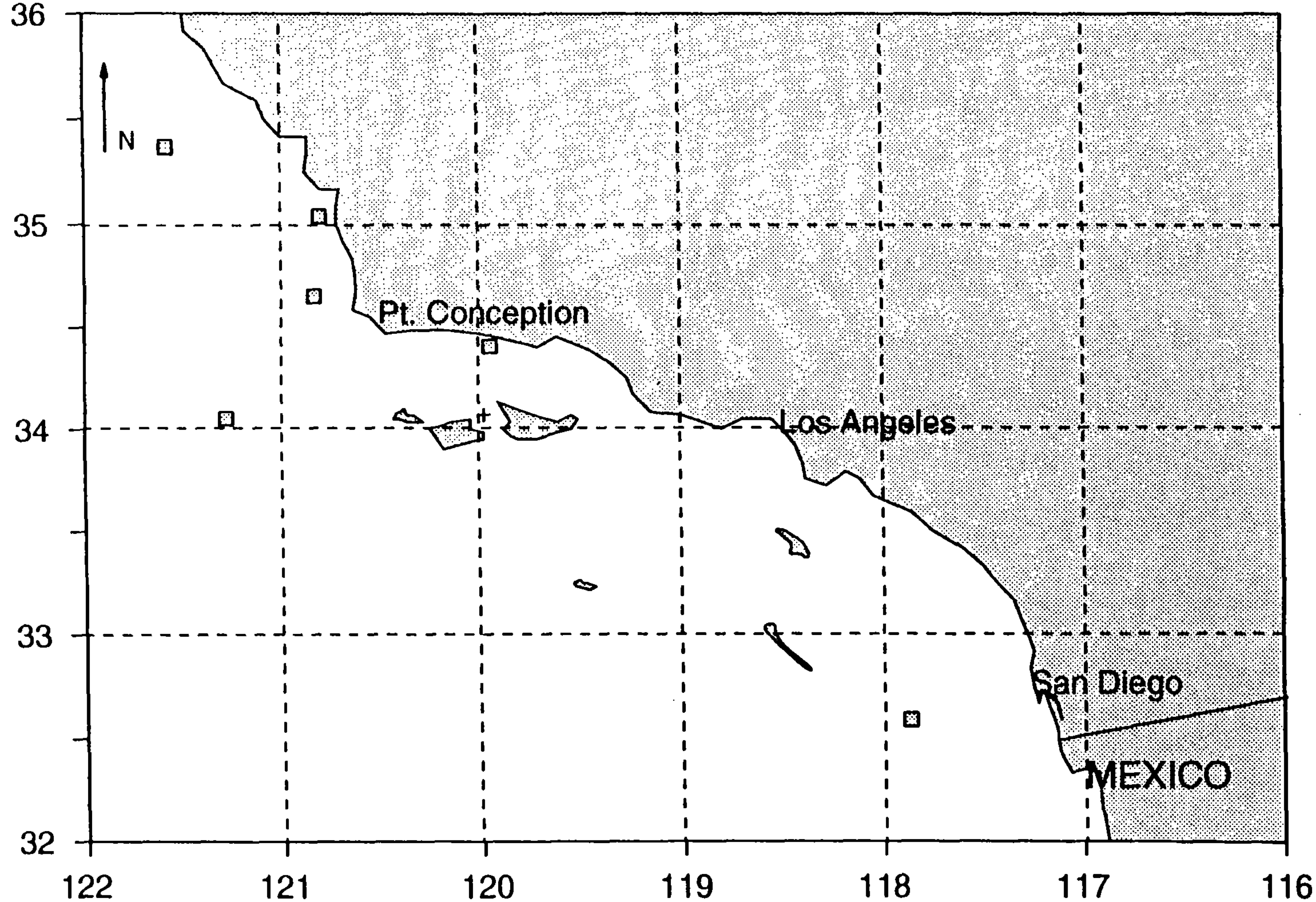

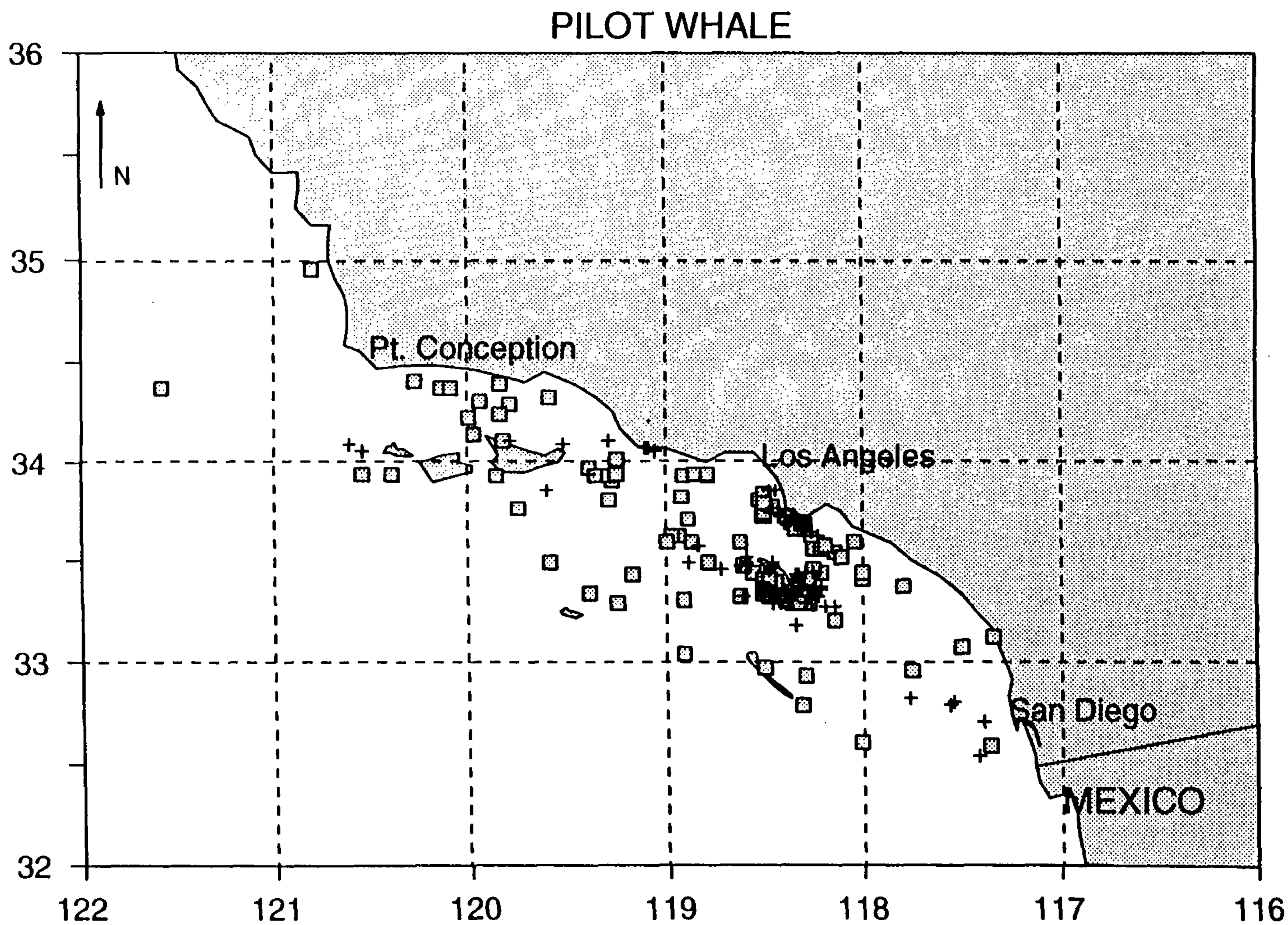

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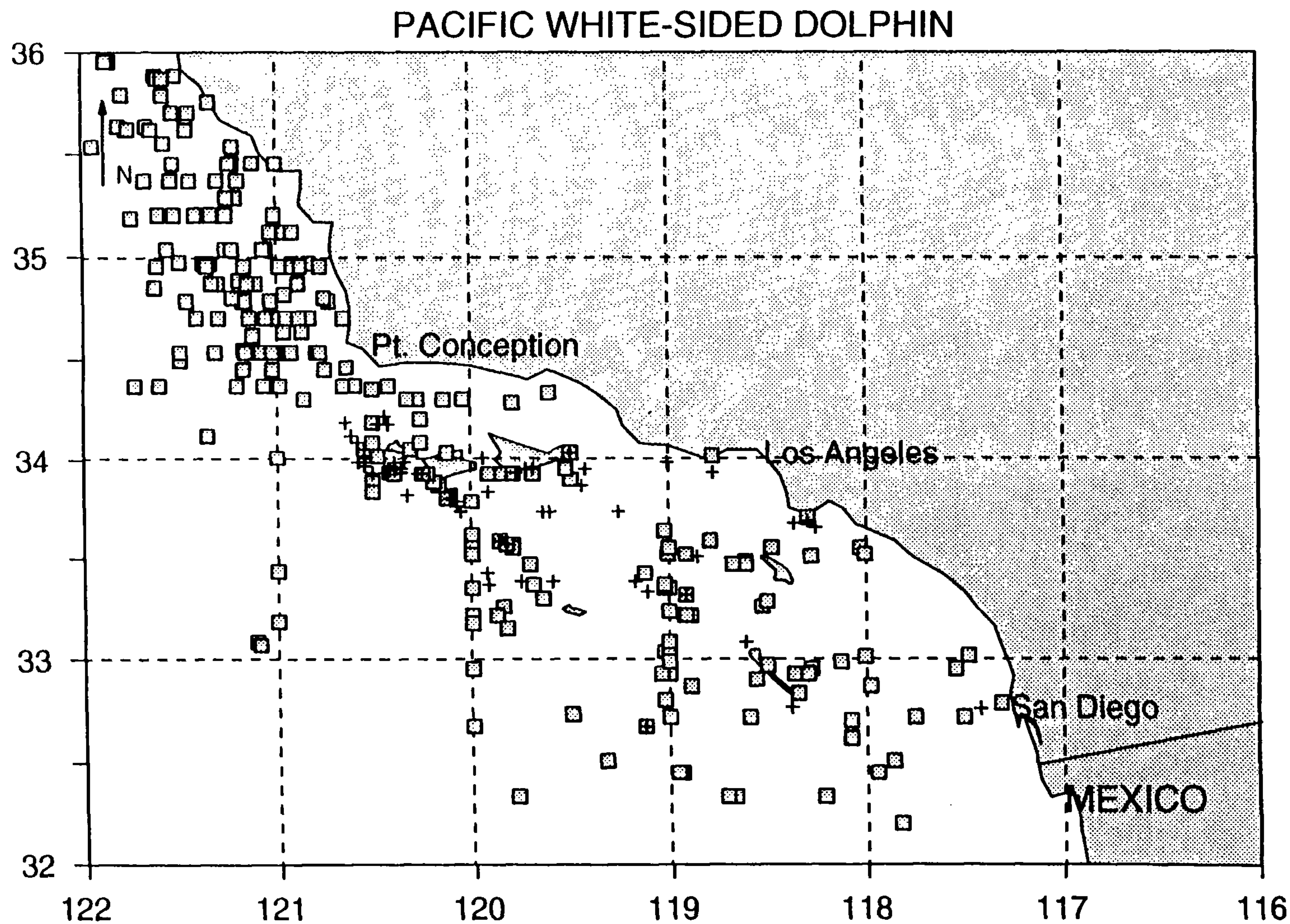
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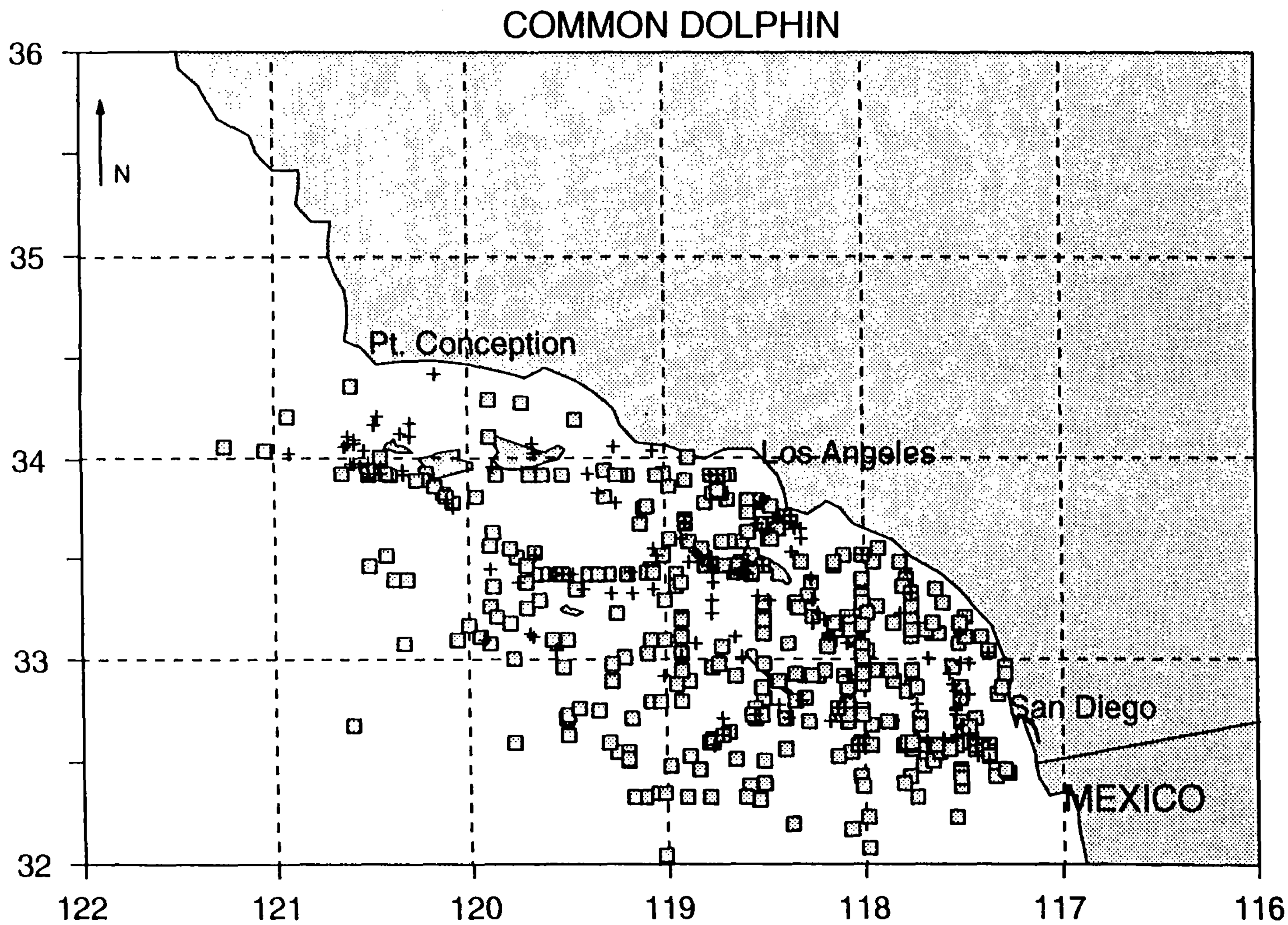
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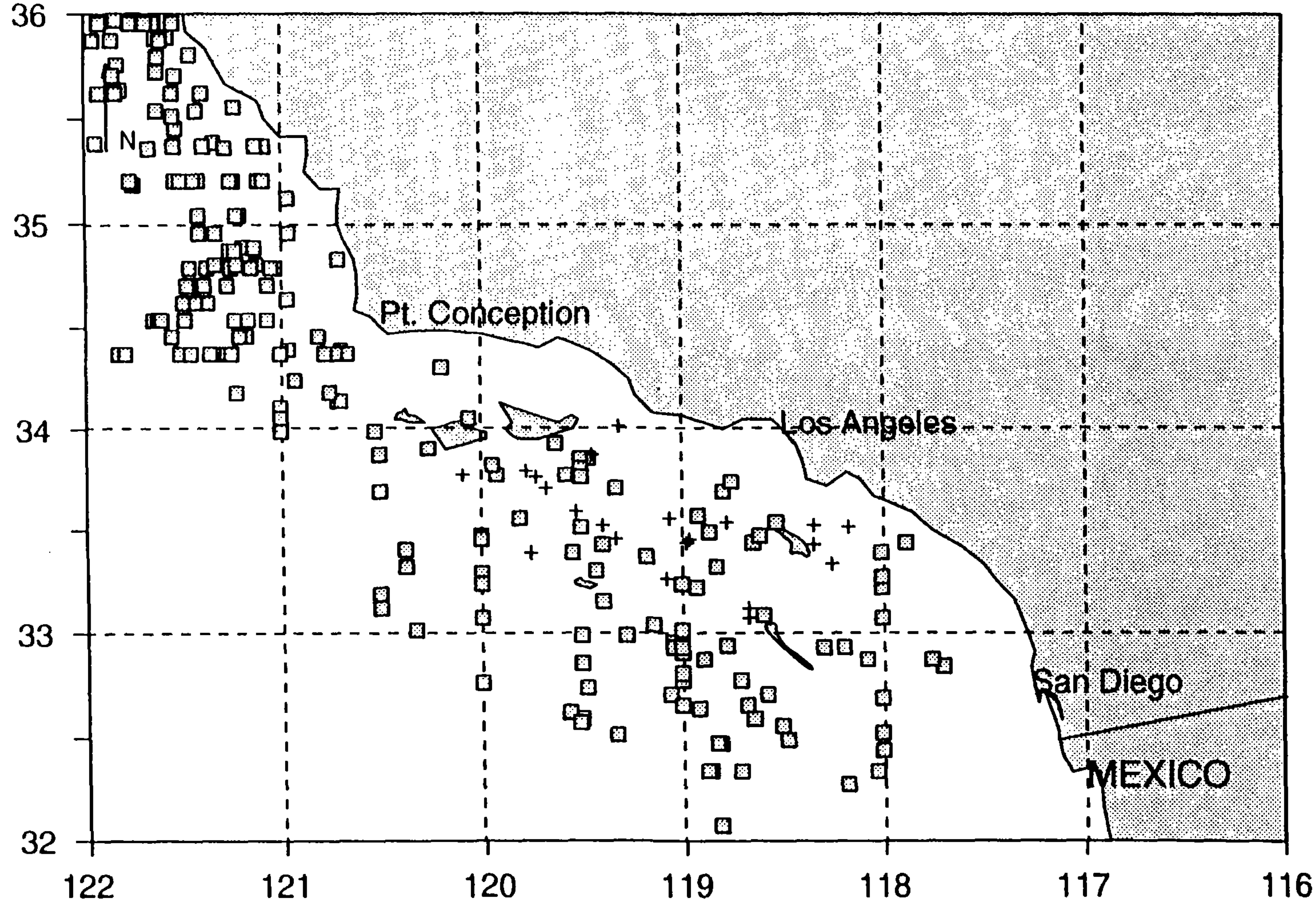
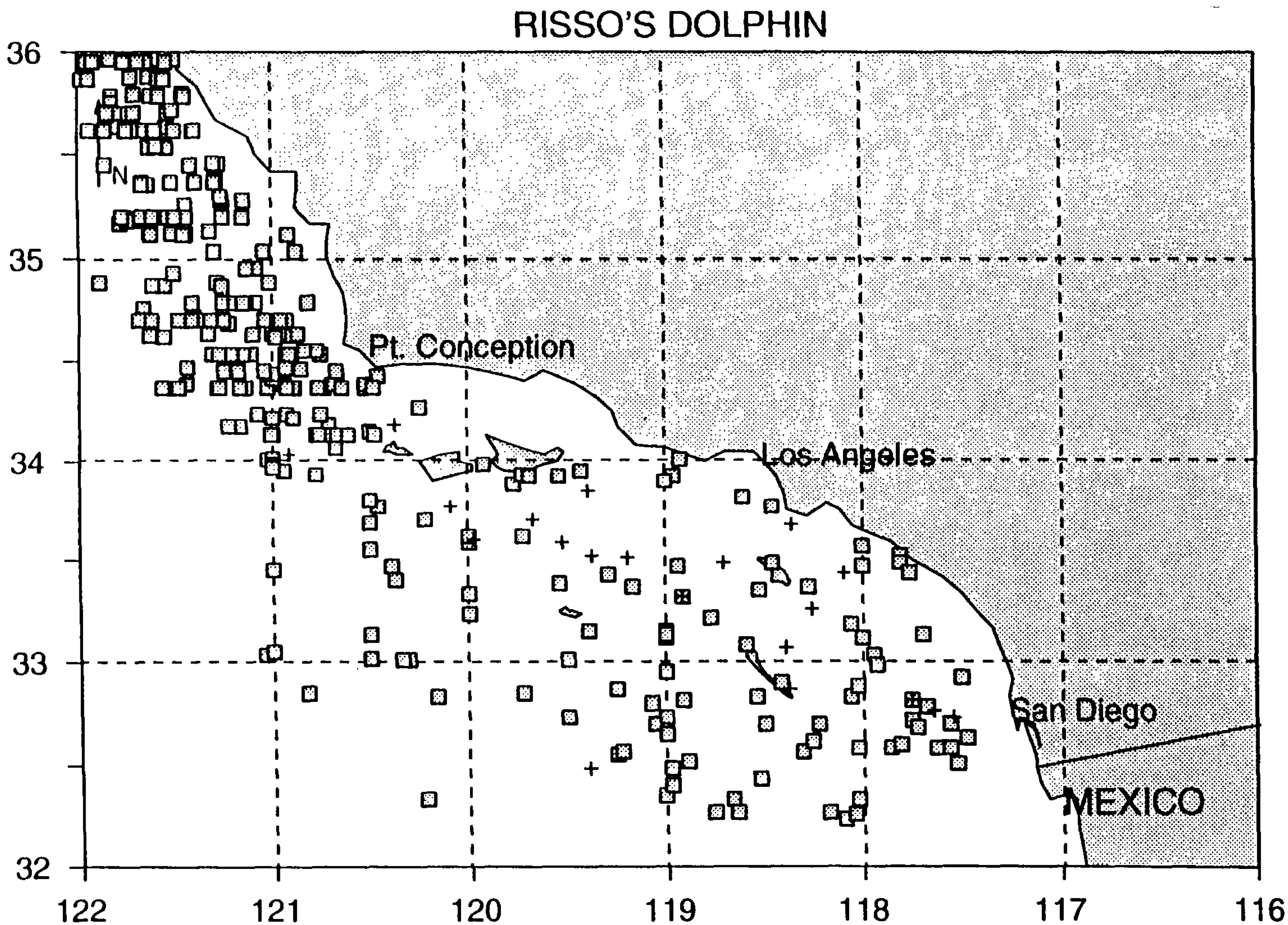
NORTHERN RIGHT-WHALE DOLPHIN





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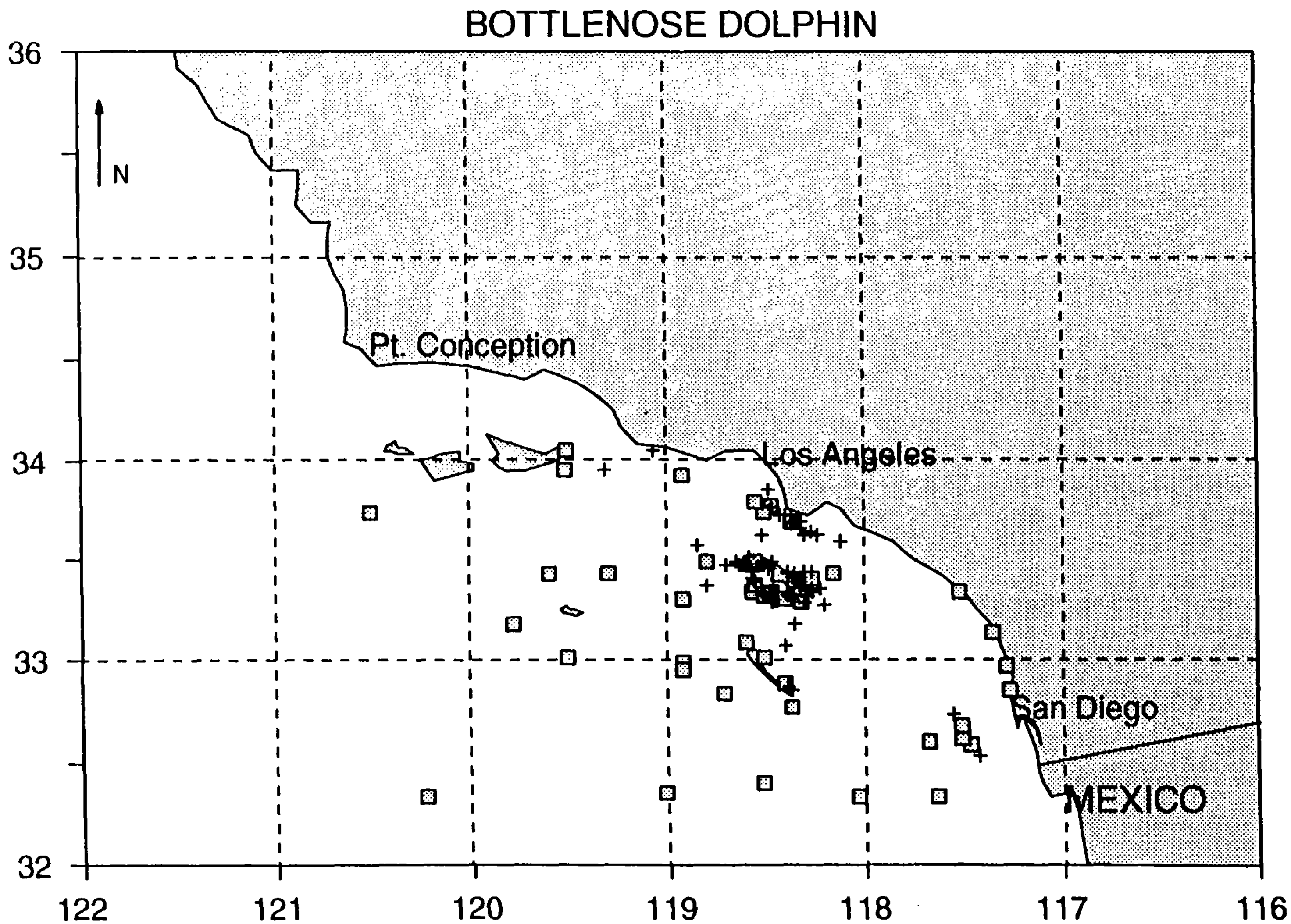
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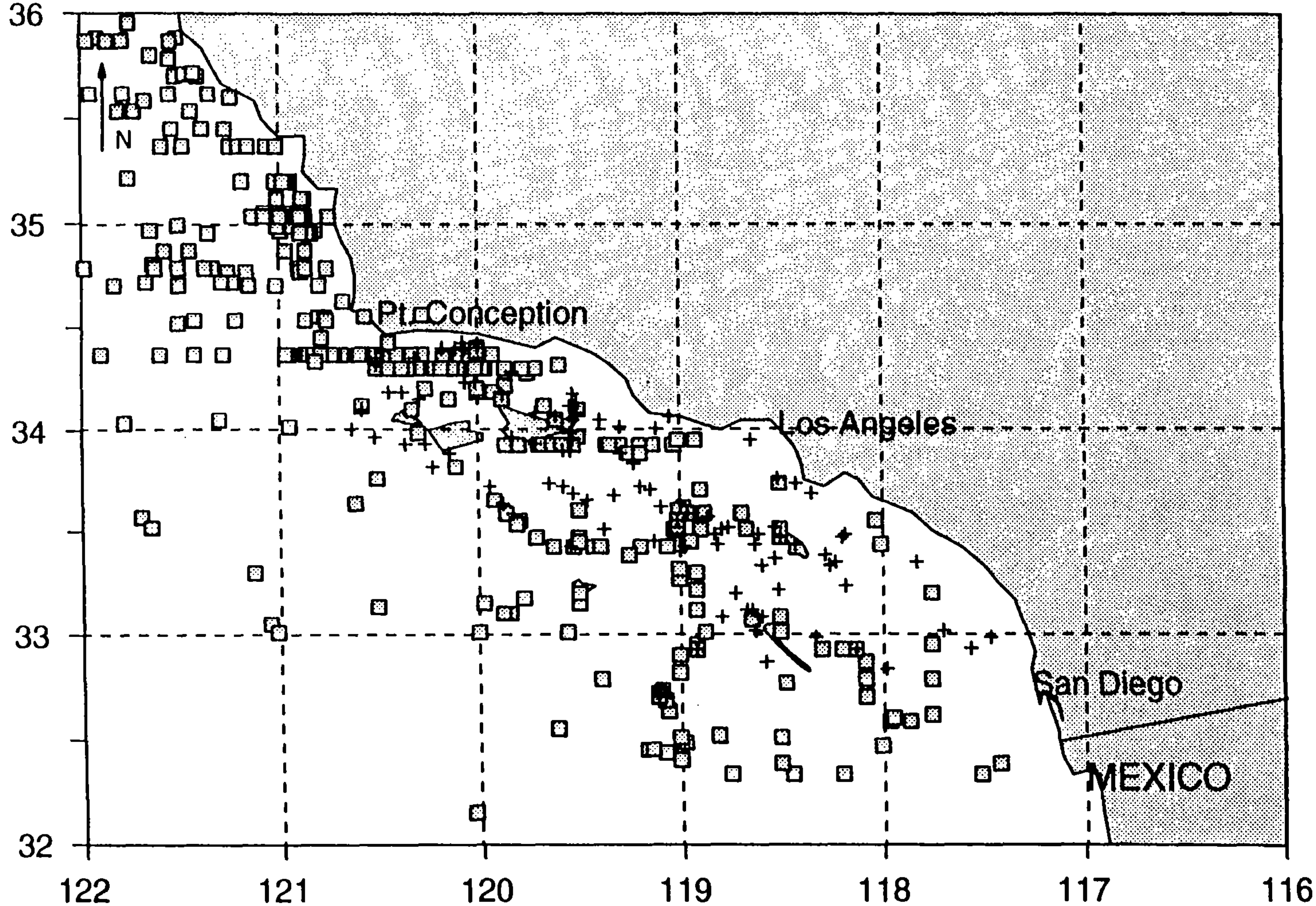
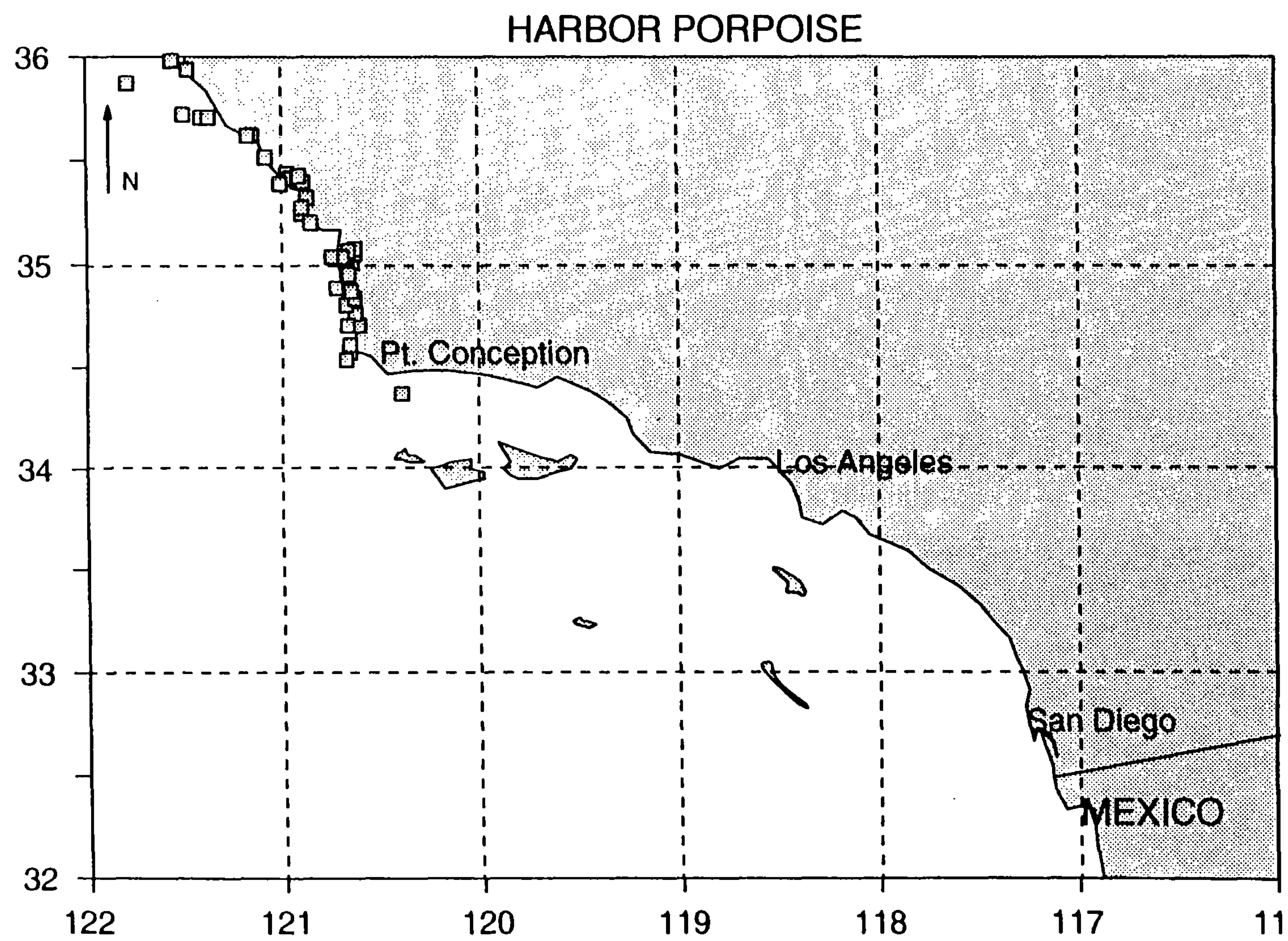
DALL'S PORPOISE

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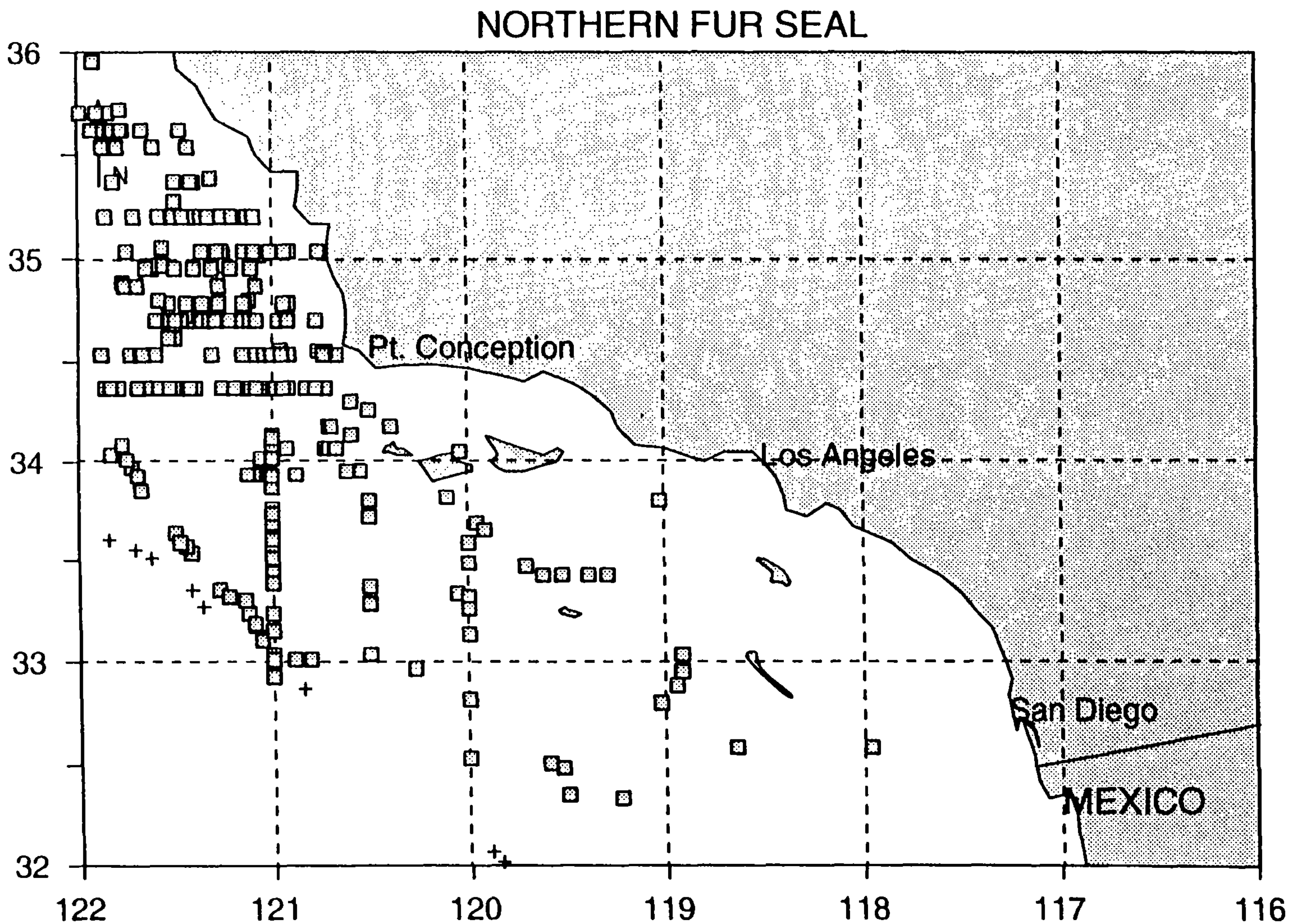
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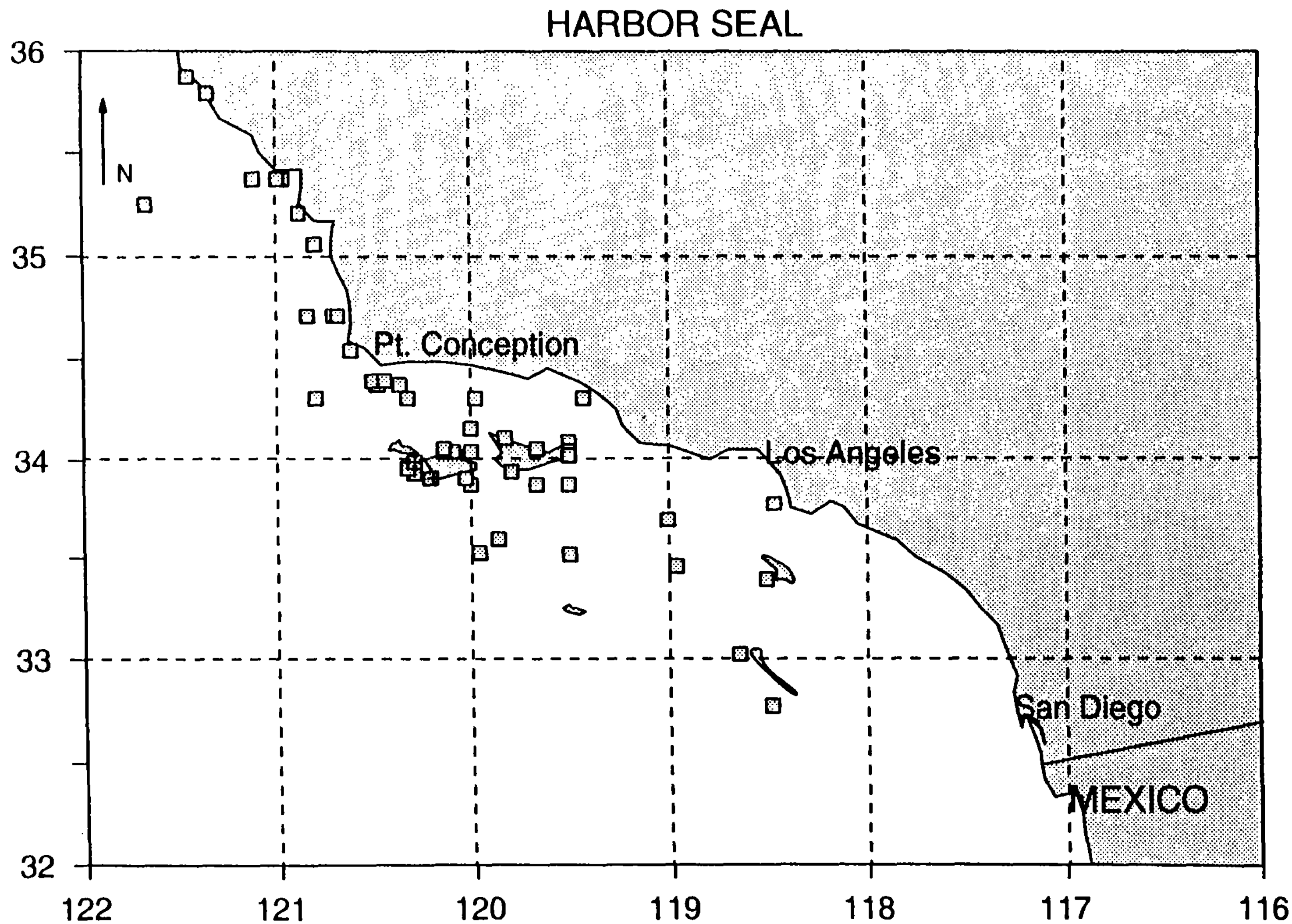
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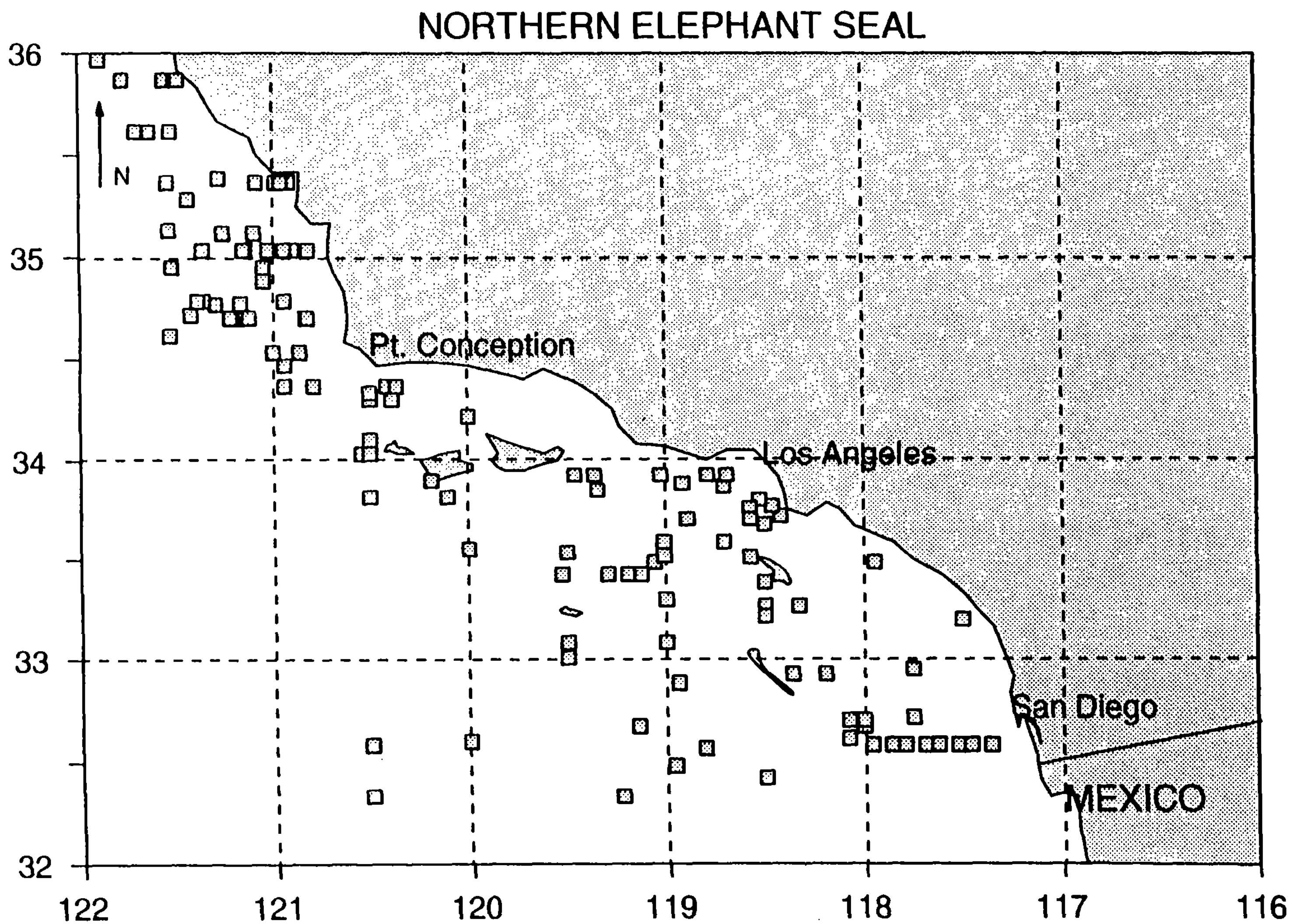
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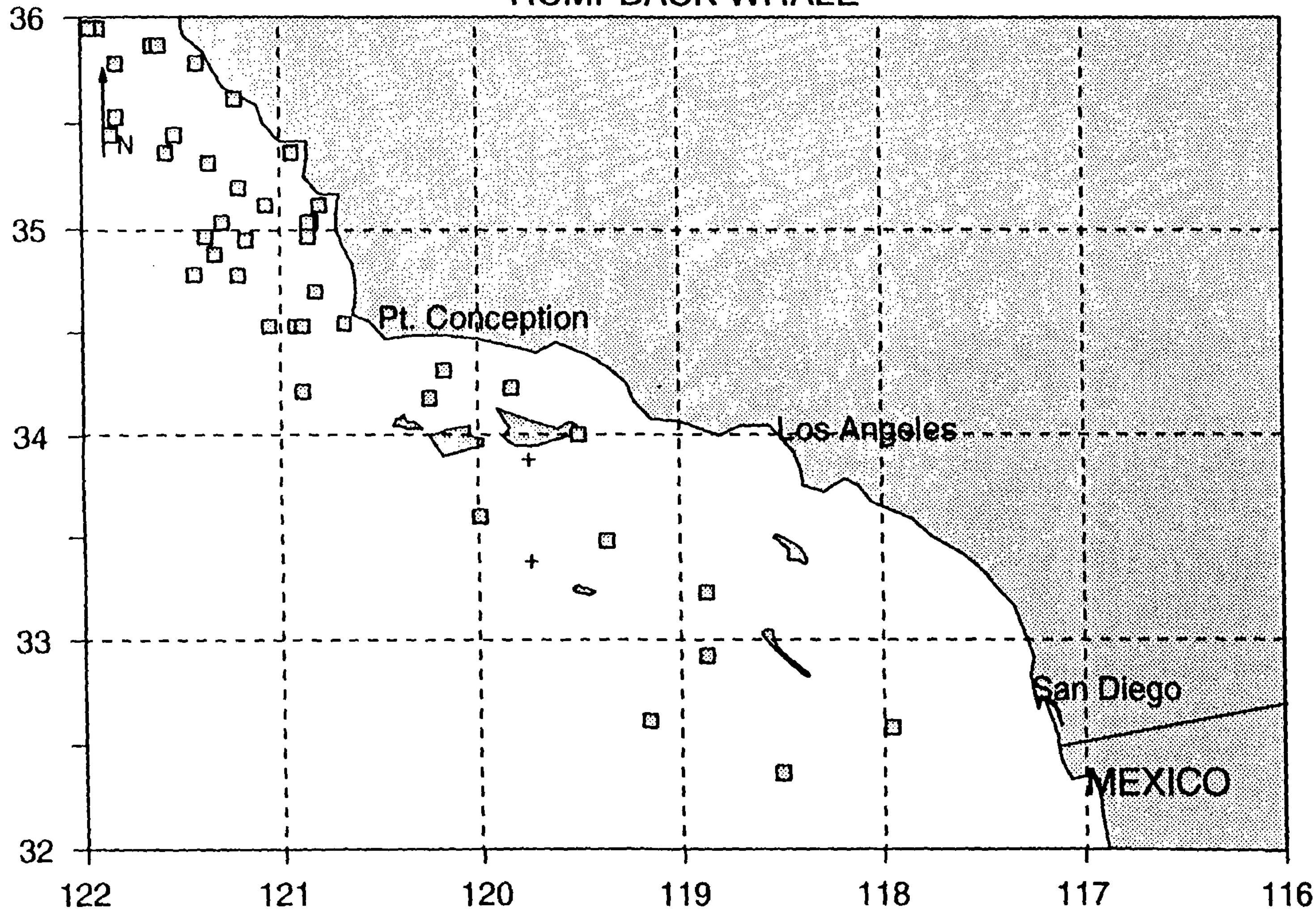
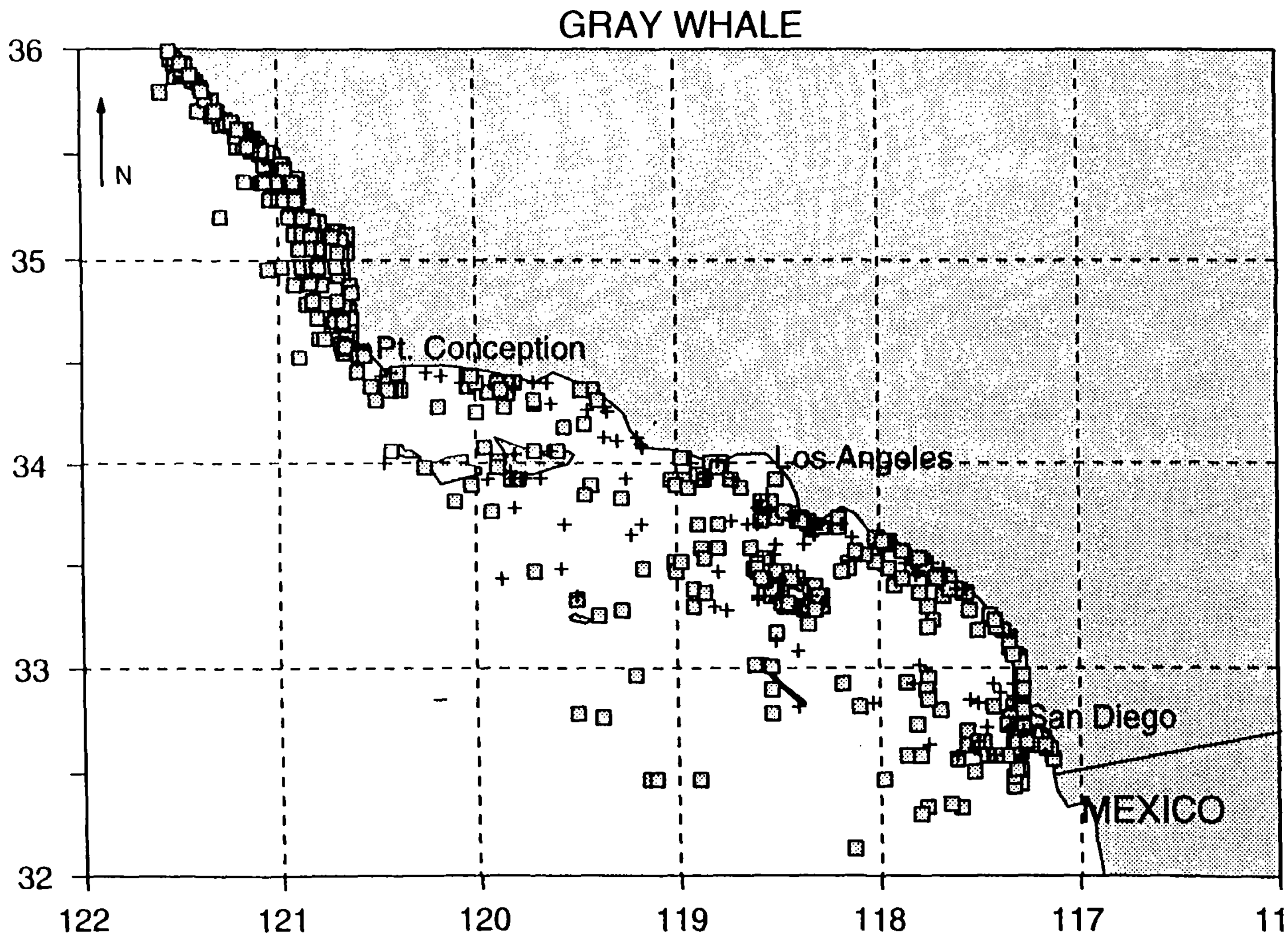
HUMPBACK WHALE





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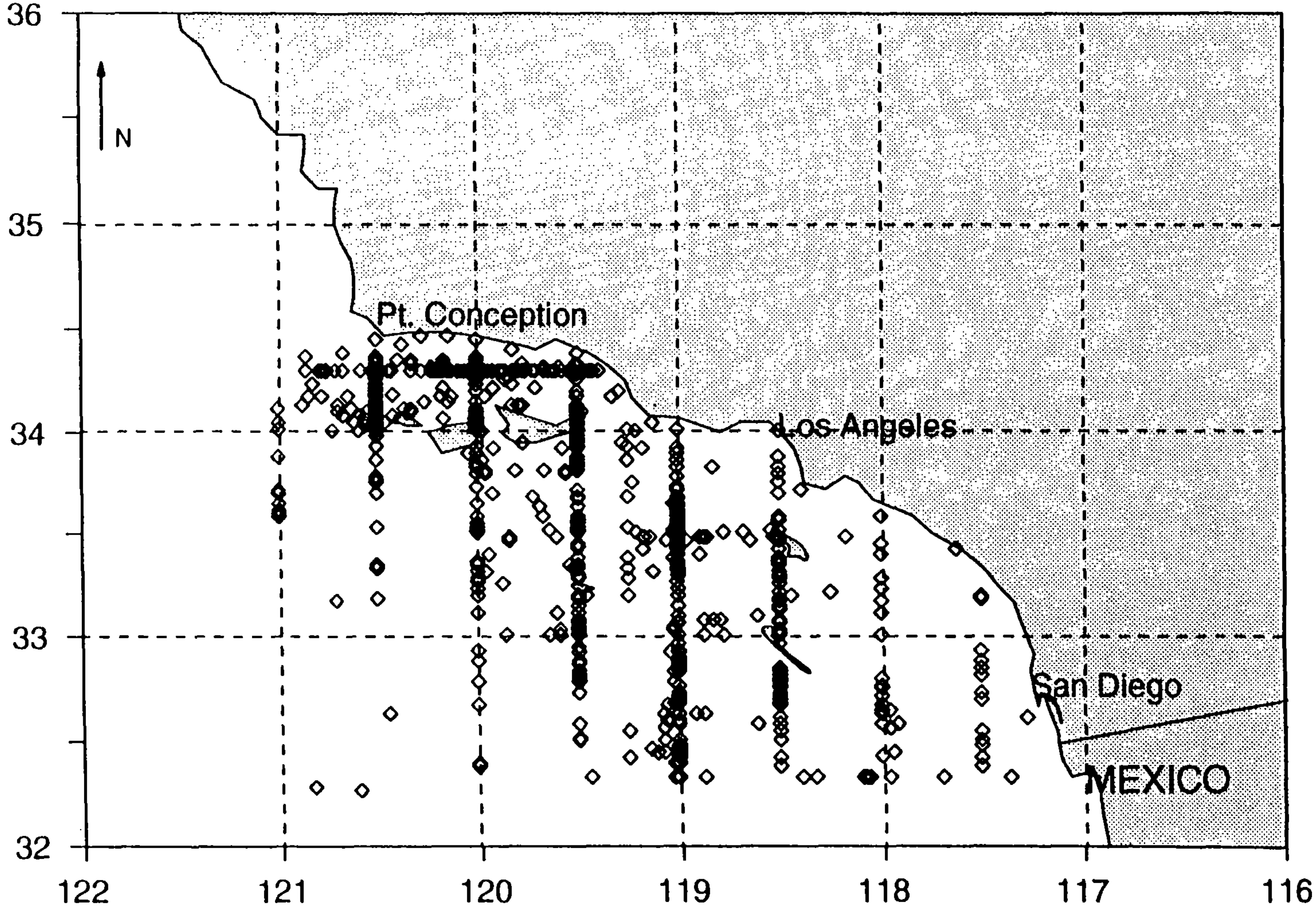

Only sightings from systematic surveys made south of Pt. Conception are shown